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Assessment of Army Aviators' Ability to Perform Individual and Collective Tasks in the Aviation Networked Simulator (AIRNET)

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13. ABSTRACT (*Maximum 200 words*)

This research evaluates the training effectiveness of the Aviation Networked Simulator (hereafter referred to as AIRNET). The research was designed to (a) assess experienced crewmembers' ability to perform selected individual and collective tasks in AIRNET and (b) identify the specific design attributes that makes it difficult for crewmembers to perform tasks to standards in AIRNET. Because the research examined only in-simulator performance, inferences about the device's training effectiveness can be drawn only from data indicating that experienced crewmembers <u>cannot</u> perform a task effectively in AIRNET. Specifically, it is assumed that tasks cannot be trained effectively in a device if they cannot be performed adequately in that device. Transfer-of-training studies are required to assess the AIRNET's effectiveness for training tasks that <u>can</u> be performed adequately in the device.

The report presents detailed data on the relative effectiveness of crewmembers performing the individual and collective tasks investigated. The report also presents detailed data on crewmember ratings of the adequacy of AIRNET for both performing and training specific tasks and conclusions and recommendations about the need to modify the design of AIRNET components.

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ASSESSMENT OF ARMY AVIATORS' ABILITY TO PERFORM INDIVIDUAL AND COLLECTIVE TASKS IN THE AVIATION NETWORKED SIMULATOR (AIRNET)

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GLOSSARY OF ACRONYMS AND ABBREVIATIONS

ADA	Air Defense Artillery
AIRNET	Aviation Networked Simulation
ARTEP	Army Training and Evaluation Program
ATHS	Automatic Target Handover System
ATM	Aircrew Training Manual
CPG	Copilot/Gunner
DARPA	Defense Advance Research Projects Agency
DOTD	Directorate of Training and Doctrine
FARP	Forward Arming and Refueling Point
FLIR	Forward Looking Infrared
FLOT	Forward Line of Troops
FOV	Field of View
ICS	Intercommunications System
ID	Identified by Type
IERW	Initial Entry Rotary Wing
IFF	Identified as Friend or Foe
JAAT	Joint Air Attack Team
MCC	Management, Command, and Control
METT-T	Mission, Enemy, Terrain, Troops, and Time Available
MTP	Mission Training Plan
NOE	Nap-of-the-Earth
OPFOR	Operations Forces
PVD	Plan View Display
RAM	Reliability, Availability, Maintainability
RL 1	Readiness Level 1
SAFOR	Semi-Automated Forces
SAR	Search and Rescue
SME	Subject Matter Expert
SOP	Standard Operating Procedure
TOC	Tactical Operations Center
USAANVC	U.S. Army Aviation Center

ASSESSMENT OF ARMY AVIATORS' ABILITY TO PERFORM INDIVIDUAL AND COLLECTIVE TASKS IN THE AVIATION NETWORKED SIMULATOR (AIRNET)

Introduction

Background

Assessments by the Directorate of Combat Developments (1982, 1983, 1986) at the U.S. Army Aviation Center (USAAVNC), Fort Rucker, Alabama, revealed deficiencies in training Army aviators to perform collective tasks.[1] Specifically, the Battlefield Development Plan (1986) identified deficiencies in the training of air-to-air, antiarmor, air assault operations, suppression of enemy air defense, special operations missions, aerial reconnaissance, combat maneuvers, search and rescue, and target acquisition and handover. The Battlefield Development Plan traced the training deficiencies to constraints that prevent the conduct of adequate training on collective tasks in the actual equipment. Among the most important constraints identified are the following:

- training ranges are insufficient in number, size, and topograghic diversity for conducting effective collective task training;
- the high cost of aircraft, fuel, ordinance, and logistic support limits the frequency with which collective task training exercises can be conducted; and
- the conduct of collective task training in the actual equipment under realistic conditions increases the likelihood of crashes and laser accidents.

Since such constraints are difficult to overcome, Army officials reasoned that collective task training may be accomplished more cost effectively in a training device. This reasoning led the USAAVNC to establish a Memorandum of Understanding with the Defense Advance Research Projects Agency (DARPA) in 1987 to develop a prototype combined arms tactical trainer that can be used to eliminate some or all of the deficiencies in collective task training. The Memorandum of Understanding between USAAVNC and DARPA led, in turn, to the development of the aviation networked simulation system, which is referred to as AIRNET.

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[1] As the term is used here, a collective task refers to a task for which success depends on the performance of (a) the crews of two or more aircraft or (b) the crew of one or more aircraft and the crew of one or more ground units.

On June 16, 1988, the Directorate of Training and Doctrine (DOTD) tasked the Field Unit at Fort Rucker, Alabama, to assist in evaluating the effectiveness of AIRNET for training Army Training and Evaluation Program/Mission Training Plan (ARTEP/MTP) and Aircrew Training Manual (ATM) tasks. In addition, the Fort Rucker Field Unit was tasked to provide recommendations about design modifications that are likely to increase AIRNET's training effectiveness.

A valid and comprehensive assessment of the training effectiveness of any training device requires the conduct of transfer of training research (research that measures the extent to which training in the device transfers to performance in the operational equipment). However, because transfer of training research is costly and time consuming, it was concluded that transfer of training research cannot be justified until the AIRNET design has stabilized. This research is based on the premise that useful, albeit limited, information about AIRNET's training value can be obtained from a study of experienced crewmembers' ability to perform selected flying tasks in AIRNET. The rationale underlying the decision to investigate in-simulator performance is as follows: if a task that an experienced crewmember performs routinely in the aircraft cannot be performed adequately by the crewmember in AIRNET, it is highly unlikely that effective training on that task can be accomplished in AIRNET. It is important to emphasize, however, that positive transfer of training cannot be inferred from evidence that experienced aviators <u>can</u> perform tasks adequately in AIRNET.

Objectives

The primary objective of the research was to assess experienced crewmembers' ability to perform collective tasks in AIRNET. However, because all collective tasks consist of a sample of individual tasks, a second objective of the research was to assess experienced crewmembers' ability to perform selected individual tasks in AIRNET. A third objective was to identify AIRNET design attributes that may contribute to crewmembers' inability to perform either collective tasks or individual tasks. A fourth objective was to assess participants' opinions about AIRNET's effectiveness for training specific flying tasks.

Method

The research was conducted using the AIRNET system located at the USAAVNC, Fort Rucker, Alabama. The research

required 4 weeks for crewmember instruction and data collection. The following subsections describe the personnel who participated in the research, the AIRNET system, the tasks investigated, the performance assessment methods, and the evaluation procedures.

Research Participants

Crewmembers

Fifteen members of an operational attack helicopter company participated in the research. The participating crewmembers included one company commander, four AH-64A attack crews (four pilots and four copilot gunners [CPGs]), and three OH-58C scout crews (three pilots and three aeroscout observers). The crewmembers' ages varied from 20 to 45 years; the median age was 26 years. The experience level of the crewmembers ranged from 8 months to over 17 years of active duty military service. Thirteen crewmembers had served in the same operational unit and had trained together as crews and teams for more than 15 months. Two crewmembers were recent graduates of the Initial Entry Rotary Wing (IERW) course and had served in the unit for less than 6 months. All of the aviators were mission qualified and had ratings of Readiness Level (RL) 1.

Most crewmembers had logged at least a moderate number of flight hours at the time they participated in the research (see Table 1). Although aeroscout observers had logged considerably fewer hours than the other crewmembers, their flight hours are typical of the moderately experienced

Table 1

Flight Hours Logged by Participating Crewmembers

Group	Flight Hours Logged Range	Flight Hours Logged Median
Attack Pilots	200 - 3700	2512
Attack Copilot/Gunner	210 - 700	375
Scout Pilots	375 - 670	410
Aeroscout Observer	180 - 200	200

aeroscout observer. As a group, the attack pilots had logged far more flight hours than the other three types of crewmembers. Only one attack pilot can be considered an inexperienced aviator (200 flight hours logged). Although the attack CPGs and the scout pilots reported fewer flight hours than the attack pilots, most of them can be considered moderately or highly experienced aviators; only one attack CPG can be considered a novice aviator (210 flight hours logged).

Evaluators

The evaluation team consisted of seven members. Four subject matter experts (SMEs) served as performance raters during the research. All performance raters were aviators (two attack and two scout) who had experience in the instruction of attack helicopter and air cavalry/ reconnaissance troop operations.

A representative from the Threat Division, Directorate of Combat Developments, supervised and manipulated the semi-automated threat forces from the SIMNET system located at Fort Knox, Kentucky. The threat SME provided subjective assessments of the tactics that crewmembers employed against the automated threat force.

A reliability, availability, and maintainability (RAM) engineer from DOTD was responsible for recording the type and frequency of system malfunctions. The en_ineer also was responsible for identifying any RAM problems other than malfunctions associated with AIRNET.

The final member of the evaluation team, a research psychologist, was responsible for coordinating all aspects of the research, including data collection and analysis.

AIRNET System

The USAAVNC AIRNET system and its components are described in detail elsewhere (see FRED Operator's Manual [Perceptronics, 1988a, 1988b] and the SIMNET User's Guide [U.S. Army Armor Center, 1989]), so only a brief description of the system is presented here.

In general terms, AIRNET is a team training simulator in which multiple cockpits are networked in a manner that enables the crew in each cockpit to interact with the crews of all other operational cockpits. Each cockpit has a

computer generated display that portrays topography, other AIRNET simulated helicopters (AH-64 or OH-58D), threat helicopters (Hind or Havoc), and a variety of ground vehicles (both friendly and threat). The computer generated visual system enables crews of all simulated aircraft to view different topography and targets or to view the same topography and targets simultaneously from different perspectives. The AIRNET system enables a crew to attack a threat individually or in combination with the crew of other simulated aircraft; conversely, threats can return fire on AIRNET crews' aircraft with a predetermined level of lethality.

The equations of motion employed simulate a generic helicopter, so the handling qualities are not intended to be the same as any specific helicopter.

Figure 1 is a schematic depiction of the functional components of the AIRNET system. Each of the components is described briefly below. No attempt has been made to depict or describe the individual computers employed to generate the extra-cockpit scene, to drive the simulated aircraft, or to transfer information from one component to another.

- Simulator Cockpits. AIRNET is equipped with eight cockpits. Each cockpit can function as a stand alone unit, but ordinarily is linked to other AIRNET cockpits and to other AIRNET components. The design characteristics of the cockpits are described in more detail in a following paragraph.

- Management, Command, and Control (MCC) Station. The MCC Station provides the capability for activating, initializing, and deactivating all AIRNET system components. In addition, MCC Station computers simulate (a) indirect fire and close air support, and (b) fuel and ammunition automatic resupply.

- Battle Master Station. The Battle Master Station provides the capability to specify the type, number, and initial location of all the simulated aircraft and ground vehicles that are to participate in a training exercise. The Battle Master Station is also used to specify the initial fuel load and ammunition load for each simulated vehicle.

- Plan View Display (PVD). The PVD provides a dynamic plan view of the simulated operations area for a training exercise. Associated controls provide the capability to tailor the display scale, icon size, and display content to meet the momentary needs of the

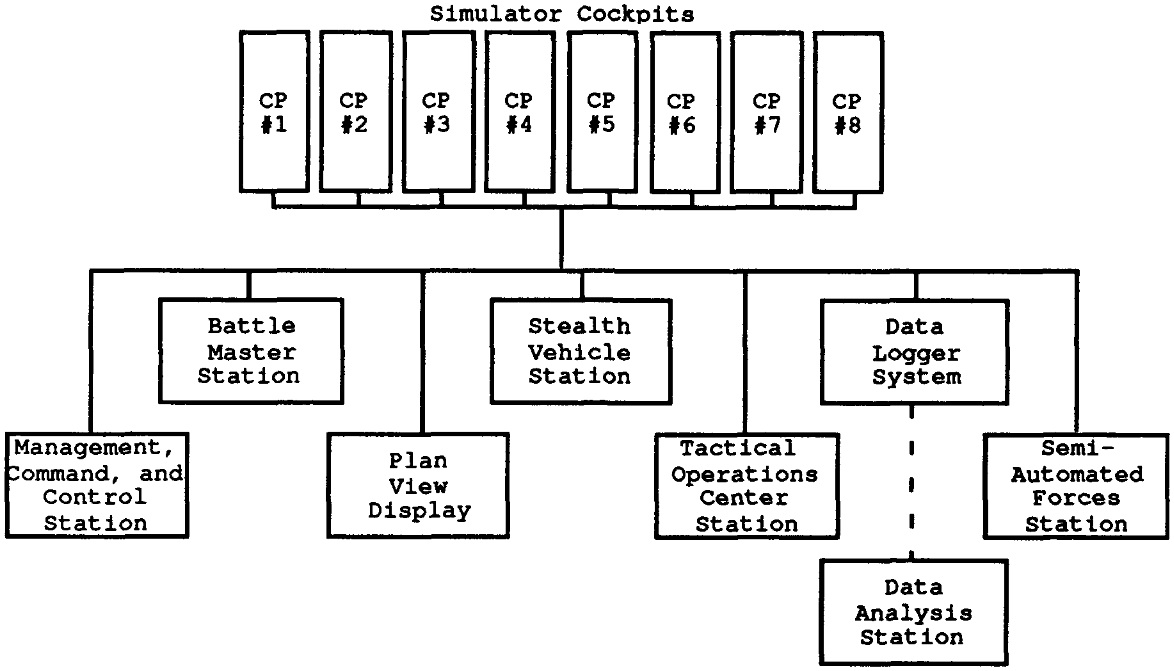

Figure 1. Main components of AIRNET.

user. Ordinarily, the display shows a contour line depiction of terrain relief and the location and status of air and ground vehicles. The intervisibility among vehicles (and other intervehicle information) is displayed on demand.

- Stealth Vehicle Station. The Stealth Vehicle Station provides the capability for a training supervisor or researcher to maneuver to and observe any location within the simulated operations area without being observed by other participants or by simulator sensors.

- Tactical Operations Center (TOC) Station. Close air support and fire support are controlled from the TOC Station. The TOC Station provides the capability to simulate the delivery of artillery fire, mortar fire, and close air support bombs to designated coordinates at designated times.

- Data Logger System and Data Analysis Station. The Data Logger System records continuous data on the location, actions, and status of all simulated vehicles. The data can be recorded on an internal

hard disk or, if the data are to be analyzed or stored, on either a 460 megabyte floppy disk or a high density magnetic tape. The Data Analysis Station provides the capability to extract selected data from the floppy disk or tape, and to analyze the data using standard statistical routines.

- Semi-Automated Forces (SAFOR) Station. As the name implies, the SAFOR Station is used to specify and control automatically the air and ground vehicles needed for a force-on-force training exercise. The computer controlled vehicles can be aligned as either threat or friendly vehicles. In short, the SAFOR Station provides the capability for including multiple simulated vehicles in a training exercise without the need for an individual to control each vehicle.

All AIRNET cockpits are generic cockpits that can be configured for either an attack helicopter (tandem seating) or a scout helicopter (side-by-side seating). The drawing in Figure 2 shows the general layout of an AIRNET cockpit. The right-rear station is the pilot station, the CPG station is in front of the pilot station, and the copilot/observer

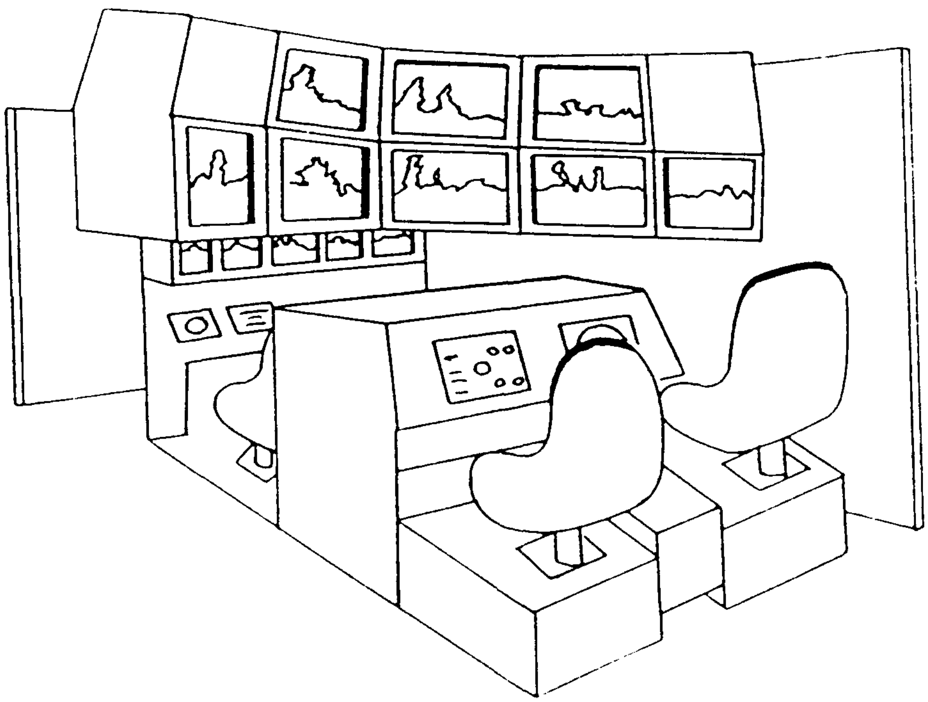

Figure 2. Drawing of an AIRNET cockpit.

station is to the immediate left of the pilot station. The computer-generated, extra-cockpit scene is shown on two banks of eight displays each. One bank of displays is located in front of and centered on the pilot station; the second is located in front of and centered on the CPG station. The viewing distance to the displays is about 24 inches. Since the upper row has two fewer displays than the lower row (see Figure 2), the viewing angle is less on the upper row than on the lower row of displays. The maximum horizontal and vertical viewing angle is 145 degrees and 80 degrees, respectively.

Each cockpit station is equipped with only the controls and instruments that are considered mission essential for the crewmember that occupies the station; hence, each crew station is configured differently. Table 2 lists the flight controls, instrument displays/indicators, and switches present in each of the three cockpit stations. A detailed description of the design and function of the crew station displays and controls is found in the AIRNET operator's manuals for the scout and the attack configurations (Perceptronics, 1988a, 1988b).

The evaluation required four generic AIRNET devices, configured as either an OH-58C or an AH-64 aircraft. The devices were alternately configured to represent a light attack (one scout and two attack) or a heavy attack (two scout and two attack) helicopter team. Semi-automated threat forces (Version 3.0) were employed during the collective task evaluation. The semi-automated forces provided interactive air, ground, and air defense artillery (ADA) threat vehicles (Ceranowicz, Downes-Martin, & Saffi, 1989; Grignetti & Saffi, 1989). This capability was provided from Fort Knox, Kentucky, through a long-haul network via a 56 kb telephone line.

Tasks Investigated

As was stated earlier, the research investigated crewmembers' ability to perform both individual tasks[2] and collective tasks in AIRNET. The 13 individual flying tasks selected for study are listed on page 10. The individual tasks selected must be performed frequently and effectively to perform collective tasks. All individual task definitions and performance standards are as specified in the appropriate ATM.

[2]The tasks referred to in this report as individual tasks are often referred to elsewhere as ATM tasks. The term is used here to ensure a clear distinction between individual and collective tasks.

Table 2

Flight Controls, Instrument Displays/Indicators, and Switches Present in the Three AIRNET Cockpit Stations

Station	Flight controls	Instrument display/indicators	Switches
Pilot	Cyclic Collective Antitorque pedals	Heading scale Lubber line Command heading Sensor bearing (64 only) Attitude indicator Radar altimeter Barometric altimeter Vertical speed Skid/slip Fuel status Engine torque RPM Airspeed Rounds of ammunition remaining (64 only) Sensor and FOV lights (64 only) Hover hold light FLIR image and symbology (64 only) Weapon selection (64 only)	Weapons activation switch (64 only) Trigger (64 only) Radio/ICS Communication control panel Master ARM/SAFE/OFF (64 only) Hover hold
Copilot/observer	None	Situation awareness display • Bearing • Range • Current position	Radio/ICS Communication control panel
Copilot/gunner	None	FLIR image and symbology Weapons selection indicator	Field of view Auto track Weapon action Weapon trigger Sensor select Manual tracker FLIR polarity Laser designate ARM/SAFE/OFF Communication control panels Radio/ICS Laser ARM/STANDBY/OFF

Note. ICS = intercommunications system; RPM = revolutions per minute; FOV = field of view; FLIR = forward looking infrared.

- Hovering Flight
- Nap-of-the-Earth (NOE) Flight
- Contour Flight
- Low Level Flight
- Acceleration
- Normal Deceleration
- NOE Deceleration
- High Speed Flight
- Vertical Masking/Unmasking
- Lateral Masking/Unmasking
- Navigation: airspeed 20 - 50 knots
- Navigation: airspeed 50 - 80 knots
- Navigation: airspeed 80 - 110 knots

In general terms, the collective tasks investigated consist of the tasks that members of a helicopter attack team must perform to accomplish representative missions. The tasks were performed in the context of a tactically and doctrinally valid scenario for each of three types of missions: a cross-FLOT (forward line of troops) deliberate air attack mission, a deliberate offensive attack mission, and a hasty attack mission. The collective tasks performed during one or more of the mission scenarios are listed below. Appendix A contains a detailed listing of the collective tasks and subtasks investigated for both the scout and the attack crewmembers.

- Conduct Movement to Holding Area
- Use Passive Air Defense Measures
- Conduct Tactical Air Movement as Part of a Movement to Contact
- Move to and Occupy a Battle Position
- Use Countermeasures Against Enemy Air Defense Artillery
- Report Intelligence Data
- Establish Contact
- Engage Targets
- Conduct Deliberate Air Attack
- Conduct Hasty Air Combat Operations
- Return to Assembly Area and Prepare for Future Operations
- Move From a Battle Position
- Conduct Joint Air Attack Team (JAAT) Operations
- Conduct Downed Aircrew Recovery

Performance Assessment Data

Two types of performance assessment data were collected during this research. First, task performance ratings were obtained from SMEs judging the adequacy with which each individual and collective task/subtask was performed. Similar ratings of collective task performance were obtained from the participating crewmembers. Second, crewmembers were required to complete questionnaire items designed to assess crewmembers' opinions about the adequacy of AIRNET components for performing and training selected tasks. The task performance ratings and the questionnaires are discussed below.

Task Performance Ratings

Participants were required to rate the adequacy with which each individual task and each collective task was performed. SMEs rated the performance of individual tasks; both SMEs and crewmembers rated the performance of collective tasks. A two step rating procedure was used. First, participants were required to rate task performance as adequate or inadequate. Performance was rated as adequate if the task being evaluated was performed to the standards specified in the appropriate ATM (individual tasks) or standards that are used to assess performance adequacy in the aircraft (collective tasks). Second, if task performance was judged inadequate, the participant was required to judge whether the inadequate performance was due principally to a crew skill deficiency or to an AIRNET system shortcoming.

For each collective task, performance was rated for (a) the composite task and (b) the subtasks that comprise the task. Appendix B presents specimens of the rating forms used to rate collective tasks. The specimen rating forms illustrate the breakout of subtasks for three different collective tasks.

Target Detection/Identification Range Measures

Measures were obtained of the maximum range at which crewmembers could detect and identify targets with unaided vision and with the AIRNET FLIR.

Other Crewmember Ratings

Questionnaires were used to assess crewmembers' judgments about (a) the adequacy of specific AIRNET

components for performing specific tasks, (b) the maximum range at which targets can be detected (direct view and FLIR), (c) the physiological discomfort and simulator sickness symptoms experienced in AIRNET, and (d) the probable training effectiveness of AIRNET. Two different questionnaires (see Appendixes C and D) were completed by all crewmembers. One questionnaire (Appendix C) was completed twice--once early and once late in the research; the second questionnaire (Appendix D) was completed at an intermediate point in time. The specific times at which the questionnaires were completed are described in the Procedures section of this report.

Questionnaire items designed to assess crewmembers' judgments about AIRNET component adequacy required crewmembers to use a 5-point rating scale to rate the adequacy of a specific AIRNET component/attribute (e.g. visual system field-of-view) for performing each of a set of tasks (e.g., hovering, forward flight, target acquisition, etc.). The AIRNET components/attributes for which adequacy ratings were obtained include (a) the computer-generated, extra-cockpit display; (b) the communication system; (c) the handling qualities (flying characteristics) of the simulated aircraft; (d) the responsiveness of the simulation to control inputs; (e) the cockpit controls, switches, displays, and indicators; and (f) the sound generation system. The verbal anchors for the 5-point rating scale are as follows:

- 1 = totally inadequate,
- 2 = somewhat inadequate,
- 3 = just adequate
- 4 = more than adequate, and
- 5 = much more than adequate.

A 5-point rating scale with different verbal anchors (see Appendix D) was used to assess crewmembers' judgments about AIRNET's potential value for training each of a set of specific tasks. The other questionnaire items were yes/no items or checklist items (e.g. maximum target detection range).

Automated Performance Measures

The Data Logger System was used to record data continuously throughout each session and to compute selected summary statistics at the end of each session. These data were used by the research psychologist to augment the SME and crewmember raters' direct observations of performance of collective tasks. However, the data were not suitable for deriving objective measures of performance on specific tasks.

Procedures

The flow diagram in Figure 3 is a schematic depiction of the procedures employed to accomplish the research. The blocks in Figure 3 depict the sequence of research tasks accomplished; the ovals depict the data generated by the associated research task. The numbers to the left of each block specify days on which the associated research task was accomplished. Each of the research tasks is described briefly below.

Administer Crewmember Instruction

All crewmembers received 3 hours of classroom instruction on the design characteristics and operation of AIRNET. The classroom instruction was followed by 6 hours of training in the AIRNET cockpit. The in-cockpit instruction was designed to familiarize crewmembers with the location and function of all displays and controls present in the station the crewmember was to occupy during the research. Crewmembers selected to occupy the pilot station were instructed on the handling characteristics of the simulated aircraft and were given an opportunity to practice a wide range of flying tasks. All crewmember instruction was accomplished during Days 1 through 8.

Administer Crewmember Questionnaire

Upon completion of the 9 hours of instruction, each crewmember was required to complete Crewmember Questionnaire #1 (Q1) for the first time. (See earlier discussion and Appendix C for details about the questionnaire.) All crewmembers completed the first administration of Questionnaire #1 on Days 9 and 10.

Assess Individual Task Performance and Target Detection/ Identification Range

Crewmembers who occupied the pilot station were assessed on their ability to perform each of the 13 individual tasks listed earlier. Each aviator performed each individual task three consecutive times. An aviator's performance was rated as adequate if he performed the task to the standards specified in the appropriate ATM on two consecutive trials. Otherwise, the aviator's performance was rated as inadequate. All evaluations were performed by a highly experienced IP.

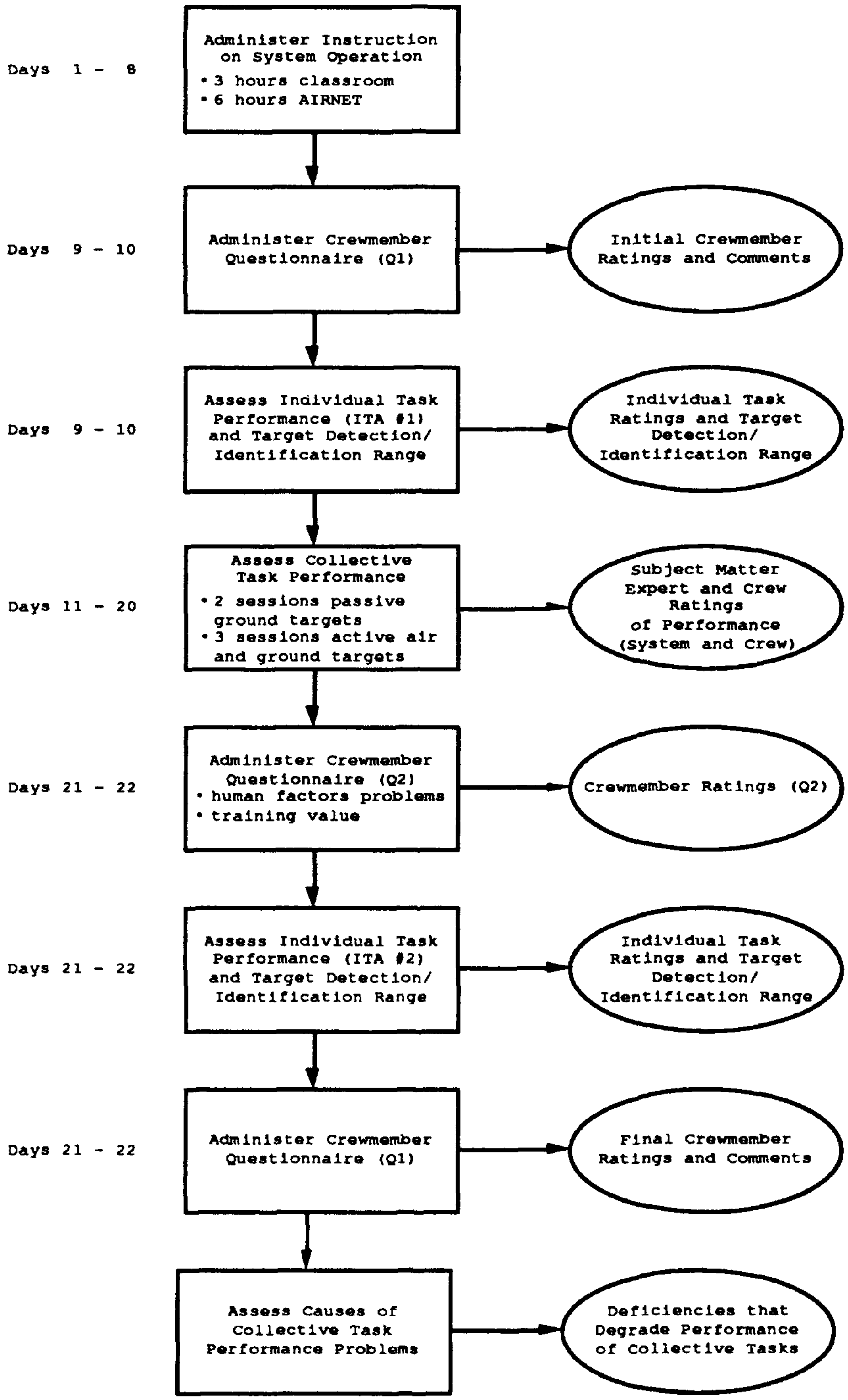

Figure 3. AIRNET training and evaluation procedure.

During the same session in which individual task performance was assessed, tests were conducted to determine the maximum range at which targets can be detected and identified with unaided vision and with the AIRNET FLIR. All crewmembers participated in the tests of target detection/ identification range with unaided vision; only the crews of the attack aircraft participated in the tests conducted with the AIRNET FLIR. For all tests, the simulated aircraft remained at a stationary location on the computer generated terrain at a fixed altitude of 50 ft. Targets were located within a 3,000 m wide corridor directly ahead of the stationary aircraft; the longitudinal axis of the simulated aircraft was aligned with the center of the corridor.

The targets were positioned at intervals of 1,000 m from the simulated aircraft's location. That is, the nearest target was located 1,000 m from the aircraft's position, the next target was located 2,000 m from the aircraft's position, and so on. The lateral position of the targets within the corridor was varied randomly, but always remained within the 3,000 m wide corridor. The most distant target used in the tests with unaided vision was located at a range of 4,000 m; the most distant target used in the tests with the AIRNET FLIR was located at a range of 8,000 m.

The targets used in the tests included: tanks, armored personnel carriers, ammunition trucks, fuel trucks, and howitzers. The targets were alternately configured as friendly or enemy. Color coding alone was used to designate a target as friendly or enemy. Any brown target was designated a friendly and any green target was designated an enemy. Hence, identification of a target as friendly or enemy required only a color discrimination (brown or green). All crewmembers had viewed all targets from various ranges, including close ranges, before commencing the test.

Crewmembers were instructed to employ normal scan procedures in searching for targets along a corridor 1,500 m to either side of the longitudinal axis of the aircraft. They were told that more than one target was located within the corridor, but they were not told the exact number of targets present. When a crewmember reported having detected a target, he was asked to identify the target as friendly or enemy. If the crewmember correctly identified the target as friendly or enemy, he was asked to identify the specific target type (e.g., M1 tank). Target detection ranges and target identification responses were recorded on a data sheet. The above procedure was repeated until the crewmember reported that he had detected and identified all targets present in the corridor.

Assess Collective Task Performance

The collective task evaluation was conducted on training Days 11 through 20. The company commander organized the scout and attack crews into two teams, light- and heavy-attack. The light team, Team 1, consisted of one scout and two attack crews; the heavy team, Team 2, consisted of two scout and two attack crews. The company commander briefed each mission and participated as the battle captain from the tactical operations center. Both teams received the same mission briefing and were exposed to the same threat arrays for each session. Table 3 shows the types of missions flown during the collective task evaluation and the type and lethality of threats encountered during each evaluation

Table 3

Mission, Type Threat, and Lethality Used During Five Sessions of Collective Task Evaluation

	Mission		
	Deliberate attack	Deliberate air attack: cross-FLOT	Hasty air attack
Training days 11 - 12	Ground vehicles; passive		
Training days 13 - 14	Ground and air vehicles; passive		
Training days 15 - 16	Ground vehicles; Lethality: novice/competent Range: 5000 m		
Training days 17 - 18		Air vehicles Air ratio: (2:1) Lethality: novice/competent Range: 5000 m	
Training days 19 - 20			Ground and air vehicles Air ratio: (1:1) Lethality: competent Range: 5000 m

Note. FLOT = forward line of troops.

session. The teams encountered only passive ground and air vehicles during the first 4 days of the evaluation. The remaining sessions were conducted against semi-automated threat vehicles.

Each team encountered only ground vehicles during the deliberate attack mission against the semi-automated threat. The enemy ADA was initiated at the novice level of lethality (probability of a hit = .10) at a range of 5,000 m. If the first engagement of the first session was successful, the threat lethality was increased to the competent level (probability of a hit = .33).

Enemy air vehicles were encountered during the cross-FLOT deliberate air attack mission. The lethality was initiated at the novice level; if the initial engagement was successful, the lethality of the vehicles was increased to the competent level for the following engagement. The density of the threat array for the deliberate air attack mission was two to one; that is, twice as many air threat vehicles were present than simulated aircraft.

The teams encountered both enemy air and ground vehicles during the hasty air attack mission. The lethality of both air and ground vehicles was set at the competent level during the hasty attack mission.

Team aircraft that crashed during the conduct of a mission were reconstituted and allowed to continue the mission. The aircraft were reinitialized at the holding area with full fuel and ammunition loads.

SME in-simulator performance ratings and postmission crew ratings were collected for each session. SMEs judged the performance of crewmembers on mission subtasks as they occurred during the mission. The composite mission performance rating was completed by the SMEs at the end of each session. Judgment about adequate composite task performance was based on the number and critical nature of the subtasks that were adequately performed for each task. The critical subtasks were identified by all SMEs as being both necessary and sufficient to accomplish the composite task. A debriefing was conducted by the company commander and the SME raters following each session.

Administer Crewmember Questionnaire

Following the final collective task evaluation session, all participants were required to complete Crewmember

Questionnaire #2 (Q2, see Appendix D). All crewmembers completed Q2 on Days 21 and 22.

Assess Individual Task Performance and Target Detection/ Identification Range

On Days 21 and 22, the crewmembers were assessed a second time on their ability to perform individual tasks and to detect and identify targets. The same procedures described for the first assessment were employed in the second iteration. The second assessment was conducted to determine the effect of the experience gained during the collective task evaluation sessions on target detection and identification performance.

Administer Crewmember Questionnaire

The final task was to administer Q1 a second time. The pilots and the aeroscout observers were required to complete Q1 a second time to determine the effect of the experience gained during the collective task evaluation sessions on their subjective ratings. Q1 was administered on Days 21 and 22.

Assess AIRNET Design Shortcomings

About 2 months after completing the data collection procedure described above, two of the SMEs who evaluated the crewmembers' performance on collective tasks participated in a post hoc assessment intended to identify the AIRNET shortcomings that contribute to collective task performance deficiencies. Each SME was provided with two types of data (compiled during the collective task evaluation). First, SMEs were provided a list of the AIRNET shortcomings identified by SMEs as probable contributors to collective task performance difficulties. Second, SMEs were provided a table showing the collective tasks for which performance was judged inadequate by SMEs or crewmembers on two or more iterations. The SMEs were instructed to (a) consider each collective task for which performance was judged inadequate, (b) identify the AIRNET design shortcomings listed that contribute to the difficulty in performing the task, and (c) identify design shortcomings, other than those listed, that contribute to the difficulty in performing the task. The two SMEs were instructed to collaborate as necessary to identify AIRNET shortcomings on which both agreed. The judgments were recorded by a member of the research staff.

Results

This section of the report describes the research results. It commences with a description of crewmembers' performance on the individual flying tasks and on the target detection/identification task. Next, crewmembers' performance on the collective tasks is described. The remainder of the section describes crewmembers' responses to the questionnaire items.

Most of the results are presented in the form of two-fold graphs (or tables). Typically, the graphs depict the proportion[3] of crewmembers who responded in a certain manner as a function of a task or equipment variable. For instance, there are graphs that show the proportion of crewmembers who performed adequately on each of a variety of tasks. There are other graphs that show the proportion of crewmembers who were able to detect or identify a target from each of a variety of viewing ranges. There are still other graphs that show the proportion of crewmembers who selected each value of a rating scale when rating the adequacy of AIRNET for performing each of a variety of tasks. The interpretation of these data requires an assessment of either (a) the absolute magnitude of one or more proportions or (b) the magnitude of the difference between two proportions.

In the present research, the most common purpose for assessing the absolute magnitude of a single proportion (or set of proportions) is to determine whether AIRNET is adequate for a given training application. This type assessment is necessarily subjective. For instance, consider the finding that approximately 85% of the aviators were able to perform the vertical masking task to standards. Does this finding suggest that AIRNET is adequate? What if the value had been 50% rather than 85%? The authors know of no purely objective methods for answering such questions. So, although the authors have made such assessments in this report, the reader must keep in mind that the assessments are subjective and that, in some instances, others may interpret the findings somewhat differently.

This research was designed to yield descriptive data rather than data with which to assess the statistical significance of difference between groups, conditions, and so on. However, there are tests to determine whether the difference between two proportions represents a true

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[3]Throughout this report, the term proportion is used in discussing statistical tests and the term percentage is used in describing specific findings.

(statistically reliable) difference or, conversely, a difference that is attributable to sampling variability. The authors have tested and reported the statistical significance of differences between selected proportions when it was judged meaningful to do so. The method used to test for the statistical significance between proportions is a normal curve test applied to the arcsine transformation of the proportions; the test is described in detail by Cohen (1977, pp. 179-211). The test was selected because it is less biased by small sample sizes than alternative tests. Cohen's method is recommended for use by readers who wish to test differences not tested by the authors.

Table 4 was prepared to facilitate readers' assessment of the statistical significance of differences between proportions. Table 4 shows the minimum difference between proportions that is required to reach the .05 level of significance (two tailed test) as a function of the sample size and the smallest of the two proportions being compared. Examination of the values in Table 4 shows that there is an inverse relationship between the size of the sample and the size of the difference required to reach statistical significance. For very small Ns, the size of the difference required to reach statistical significance is very large (as much as .64 when $\underline{n} = 4$ and $P_1 = .2$).

The reader should keep in mind that a small sample size increases the probability of erroneously concluding that there are no statistically significant differences between proportions (Type II error). This means that some differences that fail to reach the critical values shown in Table 4 are, in fact, true differences. Or, stated differently, a difference that fails to reach the critical value would prove to be statistically significant if the research was repeated with a larger sample. Unfortunately, high probability of Type II errors is the price that must be paid for the economy of a small sample size, regardless of the statistic that is used to assess the difference.

Performance on Individual Flying Tasks

The results of the assessment of aviators' performance on individual tasks are summarized in Figure 4. The bars show, by task, the percentage of iterations performed to standards. The cross-hatched bars depict performance on the first assessment (days 9 - 10); the solid bars depict performance on the second assessment (days 21 - 22). Each of seven aviators performed each task three times, so the percentage values are based on 21 iterations.

Table 4

Differences Between Proportions Required to Reach the .05 Level of Significance as a Function of N and P

Value of P_1	Sample Size: 4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
0.05	0.58	0.51	0.45	0.42	0.38	0.36	0.33	0.31	0.3	0.28	0.27	0.25	0.25	0.24	0.23	0.22	0.21	0.21
0.1	0.62	0.56	0.5	0.46	0.43	0.4	0.38	0.36	0.34	0.32	0.31	0.29	0.29	0.28	0.27	0.26	0.25	0.24
0.15	0.64	0.58	0.53	0.48	0.45	0.43	0.4	0.38	0.36	0.35	0.34	0.32	0.31	0.3	0.29	0.28	0.27	0.26
0.2	0.64	0.58	0.54	0.5	0.46	0.44	0.42	0.4	0.38	0.36	0.35	0.34	0.33	0.32	0.31	0.3	0.29	0.28
0.25	0.64	0.58	0.54	0.5	0.47	0.44	0.42	0.41	0.39	0.37	0.36	0.35	0.34	0.33	0.32	0.31	0.3	0.29
0.3	0.64	0.58	0.54	0.5	0.47	0.45	0.43	0.41	0.39	0.38	0.36	0.35	0.34	0.33	0.32	0.32	0.31	0.3
0.35	0.59	0.56	0.52	0.49	0.46	0.44	0.42	0.41	0.39	0.37	0.36	0.35	0.34	0.33	0.32	0.32	0.31	0.3
0.4	--	0.53	0.51	0.47	0.45	0.43	0.41	0.4	0.38	0.37	0.36	0.35	0.34	0.33	0.32	0.31	0.31	0.3
0.45	--	--	0.48	0.46	0.44	0.42	0.4	0.39	0.37	0.36	0.35	0.34	0.33	0.32	0.32	0.31	0.3	0.29
0.5	--	--	--	0.43	0.42	0.4	0.39	0.37	0.36	0.35	0.34	0.33	0.32	0.31	0.31	0.3	0.29	0.29
0.55	--	--	--	--	0.39	0.38	0.37	0.35	0.34	0.33	0.33	0.32	0.31	0.3	0.29	0.29	0.28	0.28
0.6	--	--	--	--	--	0.35	0.34	0.33	0.32	0.31	0.31	0.3	0.29	0.29	0.28	0.27	0.27	0.26
0.65	--	--	--	--	--	--	0.31	0.31	0.3	0.29	0.2[illegible]	0.28	0.27	0.27	0.26	0.26	0.25	0.25
0.7	--	--	--	--	--	--	--	--	--	--	--	0.25	0.25	0.24	0.24	0.24	0.23	0.23

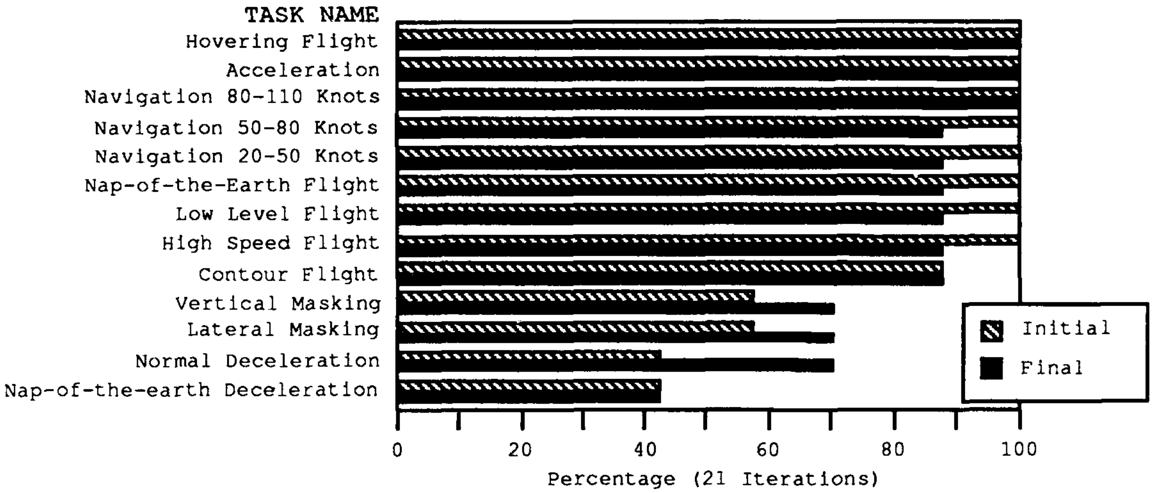


Figure 4. Percentage of task iterations performed to standards during the initial and final individual task evaluations.

Figure 4 shows that aviators performed 9 of the 13 tasks to standards on at least 85% of the iterations (see first 9 tasks listed). For 5 of the 9 tasks, fewer iterations were performed to standard on the final (85%) than the initial (100%) assessment. However, the difference is not statistically significant [$P(p_1 - p_2 = .143) \geq .05$]. Furthermore, there are no reasons to expect performance on the final assessment to be poorer than performance on the initial assessment. Hence, the following conclusions seem warranted for the first 9 tasks listed in Figure 4:

- the difference between performance on the initial and final assessments represents sampling error or rater bias, and
- the tasks can be performed to standards at least 85% of the time they are attempted.

There are four tasks for which performance appears to be a potentially serious problem. On the initial assessment, vertical and lateral masking were performed to standards on only 57% of the iterations; normal deceleration and NOE deceleration were performed to standards on only 43% of the iterations. Although performance on masking (vertical and lateral) and normal deceleration improved with practice, only 71% of the iterations of these tasks were performed to standards on the final assessment. Performance of NOE deceleration was no better on the final than the initial assessment (43% of iterations performed to standards).

All the aviators who participated in the research routinely perform lateral masking, normal deceleration, and NOE deceleration in the aircraft. So, the difficulty in performing these tasks in AIRNET can probably be attributed to design shortcomings in one or more of AIRNET's components. Interviews with crewmembers and crewmembers' responses to questionnaire items indicate that the difficulty stems mainly from the handling qualities of the AIRNET simulated aircraft. The crewmembers reported that the simulated aircraft simply does not fly like a helicopter and that the control inputs required to decelerate in a helicopter are not effective in decelerating the AIRNET simulated aircraft.

Performance on Target Detection and Identification

Figure 5 shows the percentage of targets detected and identified with unaided vision (AIRNET extra-cockpit display alone) as a function of viewing range. Performance on the initial assessment is shown in the upper graph; performance on the final assessment is shown in the lower graph. Individual bars depict the percentage of successful target detections (solid bars), identifications as friend or foe (cross-hatched bars), and specific identifications (stippled bars). All percentage values are based on a total of seven opportunities for a correct detection and identification at each viewing range (one trial by each of seven crewmembers and one target at each viewing range).

All targets at a viewing range of 1,000 m were detected and correctly identified (see Figure 5). However, the percentage of detections and correct identifications decreased dramatically at a viewing range of 2,000 m. In the initial assessment, only 57% of the targets at a range of 2,000 m were detected; only 29% were correctly identified as friend for foe, and only 14% were identified by specific type. No targets were detected or identified from a viewing range of 3,000 m or more. There was no statistically significant performance improvement on the final assessment at any viewing range.

Figure 6 shows the percentage of targets detected and identified with the AIRNET FLIR as a function of viewing range. The format and coding of data shown in Figure 6 are the same as that described above for Figure 5. However, the percentage values in Figure 6 are based on a total of only four opportunities for correct detection and identification at each viewing range. The data indicate that targets can be detected reliably (close to 100% accuracy) with the AIRNET FLIR to a range of 6,000 m. Identification of a target as a

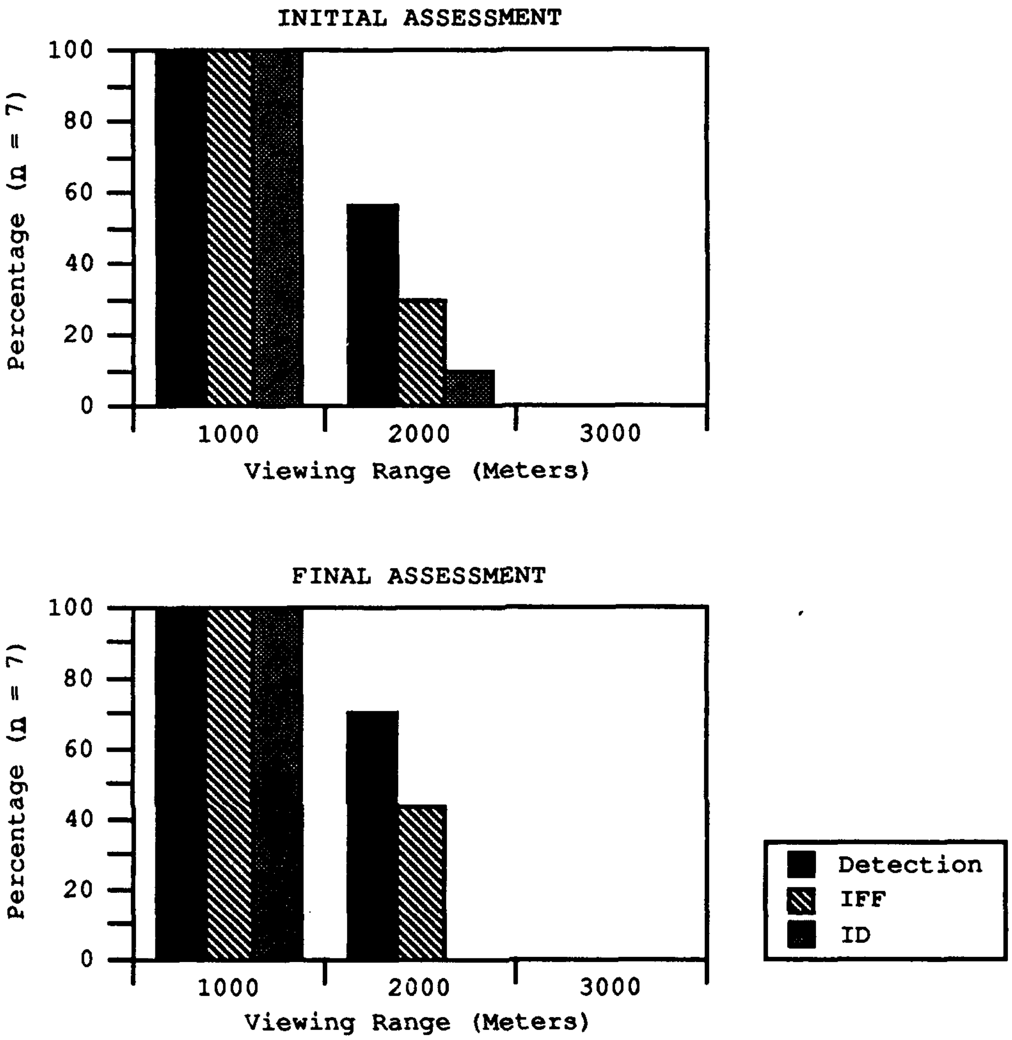


Figure 5. Percentage of targets detected, identified as friend or foe (IFF), and identified by type (ID) with unaided vision as a function of viewing range during the initial and final assessments.

friend or foe can be accomplished reliably (no more than 25% errors) with the AIRNET FLIR to a range of 4,000 m. Beyond 4,000 m, IFF performance drops to near chance level (50% of targets detected).

Specific target identification can be accomplished reliably using AIRNET FLIR at a range of 1,000 m, but the frequency of correct (specific) identifications is considerably less at ranges beyond 1,000 m. On the initial

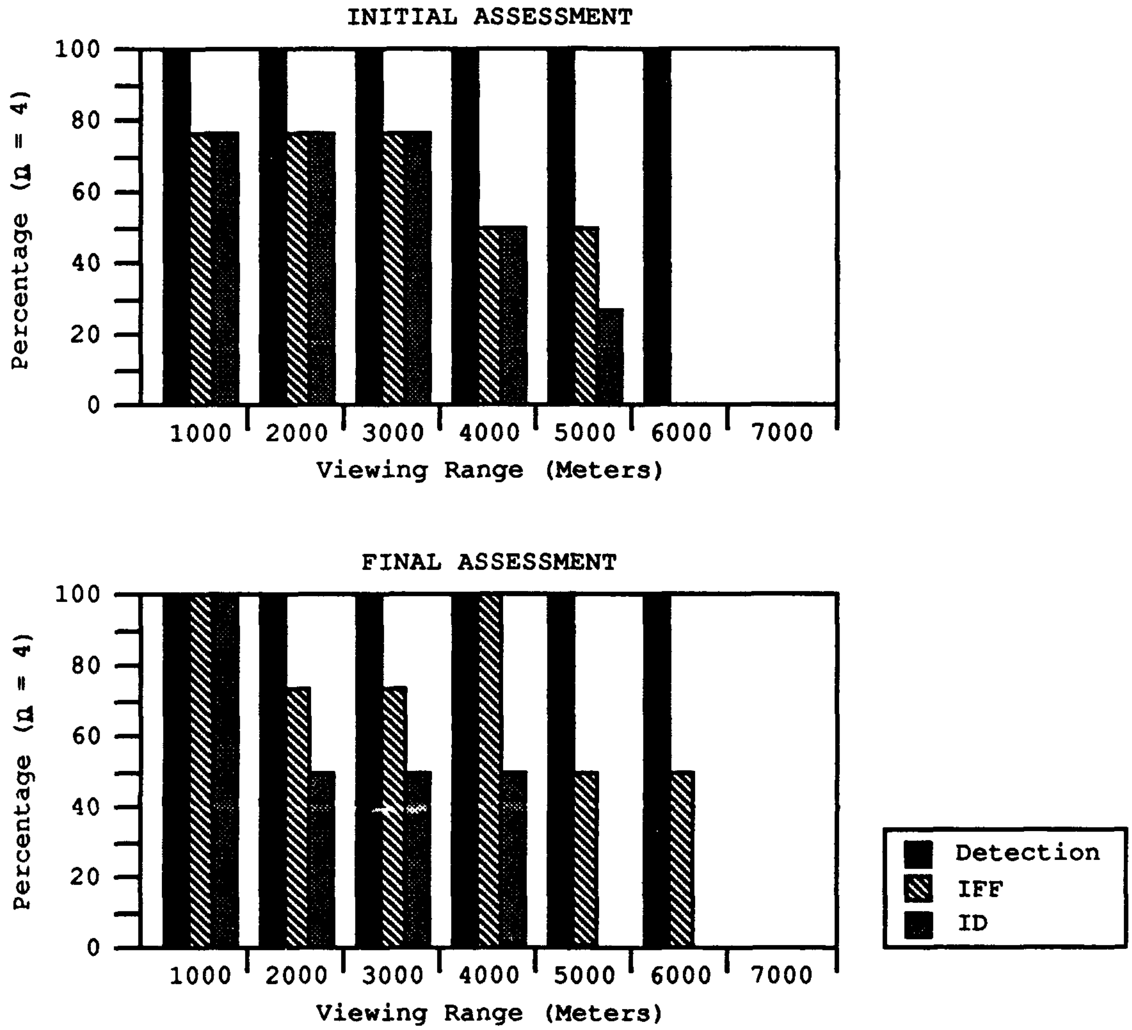


Figure 6. Percentage of targets detected and identified with the AIRNET FLIR as a function of viewing range during the initial and final assessments.

assessment, 75% of the targets were identified correctly (specific identification) at ranges of 2,000 and 3,000 m; 50% were identified correctly at a range of 4,000 m; only one target was identified correctly at a range of 5,000 m or more. Performance on specific target identification did not improve on the final assessment; in fact, performance was the same or poorer at all ranges beyond 2,000 m. Although the size of the sample is small, the data support the following conclusions about specific target identification with AIRNET FLIR:

- all or nearly all targets can be identified correctly at a range of 1,000 m or less,
- between 50% and 75% of targets can be identified correctly at ranges between 2,000 and 4,000 m,
- 25% or fewer targets can be identified correctly at a range of 5,000 m, and
- few, if any, targets can be identified correctly at ranges beyond 5,000 m.

For both unaided vision and FLIR, the maximum range at which targets can be detected and correctly identified is less in AIRNET than under typical operational conditions. (See the Discussion and Conclusions section for a comparison of target detection and identification ranges in AIRNET and in an aircraft.) Therefore, the effectiveness of collective training in AIRNET will be degraded to the extent that training is dependent upon the ability to operate in the simulated environment at target ranges comparable to the ranges at which helicopter teams are expected to function in a combat environment.

Performance on Collective Tasks

This subsection describes the data that bear on the performance of collective tasks in AIRNET. Two types of data are presented and described. First, data are presented that identify the collective tasks for which (a) performance was judged inadequate and (b) inadequate performance was attributed to an AIRNET design shortcoming. The data on collective task performance adequacy include the judgments of both the SME evaluators and the participating crewmembers. Second, data are presented that identify the specific AIRNET shortcomings that SMEs judged to be contributors to the inadequate performance of one or more collective tasks.

Most of the collective tasks investigated consist of several different subtasks. Participants were required to judge AIRNET's adequacy for performing each of the subtasks that comprised the collective tasks. The data on performance adequacy are presented by subtask.

Collective Task Performance Adequacy

The findings show that there was a general lack of uniformity in the judgments of AIRNET's adequacy for performing collective subtasks. That is, there were few subtasks for which performance was consistently judged adequate (or inadequate) from one iteration to another.

Furthermore, the judgments of SMEs and crewmembers often differed substantially.

The lack of uniformity in judgments appears to stem from two sources. First, casual observations during the evaluation sessions suggest that most of the SME evaluators and crews employed performance standards that are less demanding than the standards employed to evaluate collective performance in an aircraft. Second, the judgments of performance adequacy by crewmembers appear to be influenced significantly by the amount of effort expended in performing a subtask. That is, performance on subtasks that require extraordinary effort by crewmembers was sometimes judged inadequate by crewmembers even though SMEs judged performance to be adequate. It is the authors' opinion that these biases resulted in an underestimation of the proportion of iterations for which performance was inadequate.

To focus on problem subtasks, the data were examined to identify subtasks for which performance was judged inadequate on at least two iterations and the inadequacy was attributed to an AIRNET system shortcoming. The iteration criterion could be met in any one of three ways: two iterations judged inadequate by SMEs, two iterations judged inadequate by crews, or one iteration judged inadequate by both an SME and a crew.

The 35 subtasks of 16 collective tasks that met these criteria are listed in the left-hand column of Table 5. The second and third columns in Table 5 show, by subtask, the percentage of iterations judged inadequate by SMEs and crews, respectively. For the 18 subtasks performed by both the attack and the scout crews, the percentage values are based on seven iterations. For subtasks performed by only attack crews or by only scout crews, the numbers of iterations are four and three, respectively.

A detailed discussion of these findings is presented in the following subsection, in conjunction with data on the AIRNET shortcomings judged to be contributors to performance inadequacies. At this point, however, it should be noted that (a) neither SMEs nor crews judged performance on any subtask to be inadequate on more than 67% of the iterations, (b) performance on 14 subtasks was judged inadequate by crewmembers but not SMEs, and (c) SMEs judged performance inadequate more often than crewmembers on only six subtasks.

Table 5

Collective Subtasks for Which Performance Inadequacy was Attributed to an AIRNET Design Shortcoming on Two or More Iterations

Collective task/subtask name	%SMEs[a]	%Crews[a]
Move to Holding Area[b]		
Depart current location on time	43	43
Conduct Lines of Passage[b]		
Comply with time windows	0	43
Arrive at Holding Area[b]		
Maintain nap-of-the earth flight	0	29
Establish hasty security	29	0
Conduct Tactical Air Movement[b]		
Depart on time	14	14
Recon enemy avenues of approach	0	29
Employ remote HELLFIRE designation	14	14
Recon Battle Position[c]		
Recon attack routes into the battle position	0	33
Recon battle position; establish contact with opposing forces	0	67
Ensure maximum range shots for attack assets	0	67
Utilize Passive Air Defense Artillery Measures[b]		
Visually identify threat aircraft	14	14
Occupy Battle Position[b]		
Scout: perform security; attack: move into battle position	14	14
Scout: designate targets for attack assets; attack: establish firing positions	14	29
Scout/weapons team perform remote HELLFIRE engagement	43	29
Actions on Contact, if Not Observed[b]		
Deploy to cover	0	29
Maintain observation of enemy forces	0	29

[a]Percentage of subject matter experts (SMEs) and crews reporting a problem attributable to design shortcomings.

[b]Iterations = seven (scout and attack).

[c]Iterations = three (scout).

[d]Iterations = four (attack).

Table 5 (Continued)

Collective task/subtask name	%SMEs[a]	%Crews[a]
Actions on Contact, if Observed[c]		
Deploy to cover and employ suppressive fire	33	33
Maintain observation of enemy forces	33	33
Lead Reacts to Opposing Forces[c]		
Perform security and acquire additional targets	0	67
Maintain contact with the enemy	33	33
Conduct Target Handover[c]		
Identify targets	33	67
Handover target to attack assets and release engagement authority	33	33
Continue identification and provide security	33	67
Maintain contact with enemy	33	67
Downed Aircrew Recovery[d]		
Move to preplanned pickup point	0	50
Identify downed helicopter	0	50
Estimate aircraft damage	0	50
Report enemy situation in the area	0	50
Report accessibility of the aircraft	0	50
Perform Terrain Flight and Counter Air Defense Artillery Measures[b]		
Perform terrain flight	14	14
Expedite traversing open areas	29	14
Mask aircraft	14	14
React to Initial Contact With Opposing Forces[b]		
Identify force as enemy and report the situation	29	0
Engage Targets[b]		
Employ remote HELLFIRE with scout aircraft	57	29
Deliberate Air Combat[d]		
Maneuver opposing air threat to disadvantage	50	25

[a]Percentage of subject matter experts (SMEs) and crews reporting a problem attributable to design shortcomings.

[b]Iterations = seven (scout and attack).

[c]Iterations = three (scout).

[d]Iterations = four (attack).

AIRNET Component Design Shortcomings

During the evaluation sessions, the SMEs were instructed to record their judgments about contributing AIRNET design shortcomings each time the performance of a collective subtask was judged to be inadequate. Probably because of time pressure, SMEs seldom recorded contributing design shortcomings on the data sheet. A tabulation of the few judgments recorded on the data sheets revealed the following eight design shortcomings. The numbers in parentheses show the frequency with which each shortcoming was identified.

- Difficult to control aircraft during terrain flight (9)
- No remote designation capability (9)
- Difficult to make aircraft decelerate (8)
- Limited detection/identification range (7)
- Limited lateral FOV (7)
- Difficult to control aircraft during firing (4)
- Topography unrealistically sparse (4)
- Radio equipment difficult to operate (4)

Although these data are suggestive, they are not a reliable indication of the the types of design shortcomings that contribute to inadequate performance of collective tasks or the frequency with which such design shortcomings degrade performance. It was for this reason that two of the SMEs were recalled after the completion of the evaluation sessions to perform a post hoc assessment. It will be recalled from the Methods section of this report that two SMEs (a) considered each collective task for which performance was judged inadequate and (b) identified the AIRNET design shortcomings that, in their judgment, contributed to the difficulty in performing the task. The results of the post hoc assessment are presented below.

In all, 80 shortcomings were identified for the 35 problem subtasks (performance inadequate on at least two iterations, and inadequate performance attributed to AIRNET shortcoming). The number of shortcomings identified per subtask varied from 1 to 4. The 80 design shortcomings can be classified into 13 types. Four types were associated with temporary reliability or maintenance problems that do not constitute a fundamental design problem; these shortcomings are not discussed further. Table 6 shows the type and relative frequency of the shortcomings that are not associated with temporary reliability or maintenance problems.

The types of shortcomings identified during the post hoc assessment are similar, but not identical, to the types of shortcomings identified during the performance evaluation

Table 6

Type and Relative Frequency of AIRNET Component Design Shortcomings Identified for 35 Problem Collective Subtasks

AIRNET component design shortcoming	Percentage of tasks[a]
Limited detection/identification range	45.71
Limited lateral field of view	31.43
Difficult to control aircraft during terrain flight	25.71
Difficult to make aircraft decelerate	20.00
Topography unrealistically sparse	11.43
No remote designation capability	8.57
Search and rescue operations not realistic	5.71
Difficult to control aircraft during firing	2.86
No automatic target handover system	2.86

[a]Values represent the percentage of problem collective subtasks (n = 35) for which associated shortcoming was judged to have contributed to inadequate performance.

sessions (see list on page 30). Three shortcomings were not common to both lists: radio equipment difficult to operate (evaluation sessions only), search and rescue (SAR) operations not realistic (post hoc assessment only), and no automatic target handover system (ATHS) (post hoc assessment only). There is only a moderate degree of commonality in the frequency with which the design shortcomings were identified during the performance evaluation sessions and the post hoc assessment. Some of the differences stem from the fact that the data from the performance evaluation sessions include all subtasks, whereas the data from the post hoc assessment include only the 35 problem subtasks.

Although all the data should be taken into account in considering desirable AIRNET improvements, the authors believe that the data compiled during the post hoc assessment (Table 6) provide the best estimate of the importance of AIRNET design shortcomings. The best index of the importance of a shortcoming is the percentage of tasks that were adversely influenced by the design shortcoming. Such percentage values are shown in the right-hand column of Table 6.

Many tasks are adversely influenced by shortcomings in the AIRNET visual system. These data clearly indicate that the two most important shortcomings are limited detection and identification range and limited lateral FOV. As would be expected, such shortcomings degrade collective tasks that require crewmembers to search for, detect, and evaluate objects at representative standoff ranges. Listed below are subtasks for which performance was degraded by limited FOV, limited viewing range, or both:

- establish hasty security (FOV),
- recon enemy avenues of approach (FOV),
- recon attack routes into the battle position (FOV),
- recon battle position and establish contact with opposing forces (both),
- ensure maximum range shots for attack assets (range),
- visually identify threat aircraft (range),
- perform security and move into battle position (range),
- establish firing positions (range),
- maintain observation of enemy forces (range),
- perform security and acquire additional targets (both),
- maintain contact with the enemy (range),
- identify targets (range),
- handover target to attack assets and release (range),
- continue identification and provide security (both),
- continue contact with enemy (both),
- identify downed helicopter (both),
- report enemy situation in area (both),
- identify force as enemy and report the situation (both), and
- maneuver opposing air threat to disadvantage (both).

Two other visual system shortcomings are associated with the realism of features portrayed by the computer generated display system. One shortcoming is that topography is unrealistically sparse; SMEs identified this shortcoming as a contributor to inadequate performance for about 11% of the problem subtasks. The subtasks degraded by sparse topography are ones in which crewmembers must deploy to cover or mask their aircraft during an attack on targets. The other shortcoming is the lack of realism of SAR operations; this shortcoming contributed to inadequate performance of only one subtask. It is of interest to note that there is no

indication that unrealistic display features contributed to spatial disorientation or to errors in distance or velocity judgments.

The second most important class of shortcomings is associated with difficulties in controlling the simulated aircraft in certain circumstances. Shortcomings of this class include: (a) difficult to control aircraft during terrain flight (about 26% of subtasks), (b) difficult to make aircraft decelerate (20% of subtasks), and (c) difficult to control aircraft during firing (about 6% of subtasks). Together, these three shortcomings contributed to the inadequate performance of about 31% of the problem subtasks. The subtasks that are degraded tend to be among the most important ones. Difficulty in controlling the simulated aircraft at low altitudes degrade NOE navigation, deployment to cover, masking, and firing. Even if the pilot is able to maneuver the aircraft in these situations, it is likely that the pilot's attention will be distracted from tactical tasks or that high workload will prevent the performance of the tactical tasks. Furthermore, difficulties in controlling the simulated aircraft are certain to lead to crashes, which interrupt training for the entire team.

The remaining two shortcomings listed in Table 6 are associated with aircraft capabilities that AIRNET does not have. Performance of some subtasks was not possible because AIRNET provides no remote designation capability and has no ATHS. The lack of these two capabilities degraded performance on about 11% of the 35 problem subtasks. Although a relatively small percentage of subtasks is degraded by the lack of a remote designation and ATHS capability, they are tasks for which success is heavily dependent upon precise team coordination and, therefore, are ideally suited for a team training device such as AIRNET.

In the post hoc assessment, SMEs did not identify any subtasks for which inadequate performance was due to shortcomings in communication system. However, spontaneous reports by crewmembers indicate that the communication system controls are difficult to operate and that there are too few communication channels. These spontaneous reports are supported by the questionnaire data presented in the next section.

Responses to Questionnaire Items

The data reported in this section of the report are tabulations of participants' responses to items that appear in one or both of the questionnaires. It will be recalled

from the Methods section that both SMEs and crewmembers completed Questionnaire #1 (Q1, Appendix C) on two occasions--once before the performance assessment sessions and again immediately after completing the sessions. Results labeled _initial_ refer to responses on the first administration of Q1; results labeled _final_ refer to responses on the second administration of Q1. A comparison of the initial and final responses to the same item provides an indication of the extent to which the experience gained during the performance evaluation sessions influenced participants' judgments about the adequacy of AIRNET components.

In addition, participants completed Questionnaire #2 (Q2, Appendix D) immediately after completing the collective task assessment sessions. Some items on Q2 were the same as items on Q1. For items common to both Q1 and Q2, only the initial and final responses on Q1 are reported. The Q2 responses to common items were so similar to the final Q1 responses that nothing is gained by presenting and discussing Q2 responses.

Most questionnaire items required the participant to rate the adequacy of an AIRNET system component or feature for performing each of a set of prescribed tasks. A 5-point rating scale was used in all cases. The rating values and verbal anchors are as follows:

- 1 = totally inadequate,
- 2 = somewhat inadequate,
- 3 = just adequate enough,
- 4 = more than adequate, and
- 5 = much more than adequate.

After examining the results, the authors judged that presenting and discussing the percentage of participants who selected each of the five rating values would add little useful information. Hence, the results are presented simply as the percentage of respondents who judged the AIRNET component or feature in question to be inadequate (rating values 1 or 2) or adequate (rating values 3, 4, or 5). For example, if 5% of the participants selected a rating value of 1 (totally inadequate) and 20% selected a rating value of 2 (somewhat inadequate), the results are described by stating that 25% of participants rated the component inadequate.

The following subsections describe participants' judgments of the adequacy of the visual system, the flight characteristics, the crew stations, and the communication equipment. Also, data are presented on participants' judgments about the maximum target acquisition range (unaided and FLIR) and the probable training value of AIRNET.

Judged Adequacy of Visual System Attributes

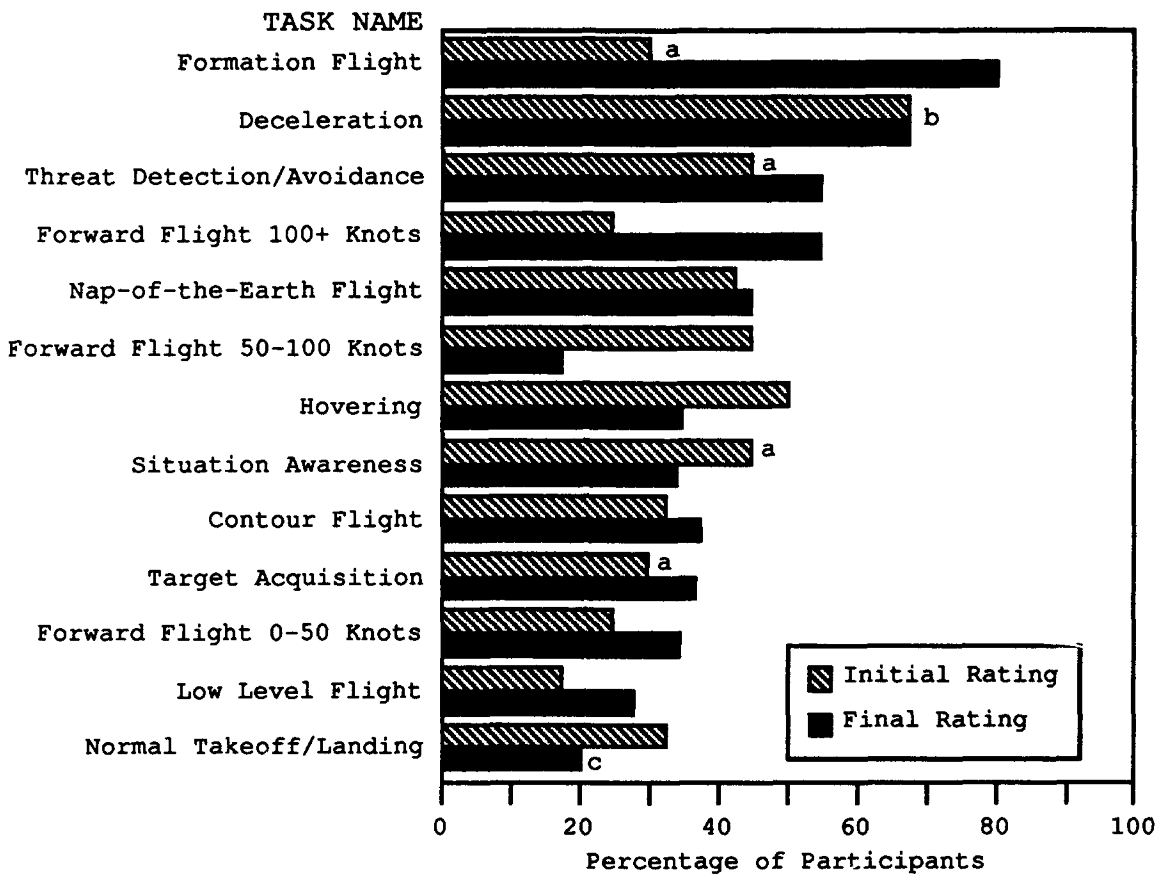
Because the visual system is certain to influence the training effectiveness of any simulation system, both Q1 and Q2 contain items that required participants to judge the adequacy of the visual system in general and the adequacy of specific attributes of the visual system. Because the adequacy of a visual system is at least partially task dependent, every visual system item on the questionnaires required participants to evaluate the adequacy of the visual system for performing each of a limited set of prescribed tasks.

Described below are crewmembers' judgments about the adequacy of the (a) lateral FOV, (b) visual cues and visual scene (general), (c) stability and smoothness of the visual scene, (d) scene realism, and (e) discernibility and realism of topographic features. Also presented are crewmembers' judgments about the visual system's propensity for creating visual problems.

Lateral FOV. Participants were required to rate the adequacy of lateral FOV for performing each of 13 tasks (see Q1, item 1). The initial and final ratings are summarized in Figure 7. The values represent the percentage of participants who judged lateral FOV to be inadequate for performing the associated task. The tasks are ordered in terms of the percentage judged inadequate on the final rating; the task with the largest percentage is listed first.

For nine tasks, more participants judged lateral FOV inadequate on the final rating than on the initial rating. Hovering, situation awareness, and normal takeoff and landing are the only tasks for which more participants judged lateral FOV to be inadequate on the initial than on the final rating. The results suggest that the experience gained during the collective task evaluation sessions gave participants a better understanding of the extent to which a limited lateral FOV degrades performance on some tasks. However, the difference was large enough to reach statistical significance for only one task, formation flight. Because the final judgments are based upon more experience than the initial judgments, the discussion of ratings by task is limited to judgments of lateral FOV adequacy on the final rating.

The results indicate that lateral FOV is judged most inadequate for formation flight, deceleration, threat detection and avoidance, and tasks that require flying very low or very fast. Approximately 81% of the participants judged lateral FOV inadequate for formation flight, and approximately 67% judged lateral FOV inadequate for



[a]n = 7; [b]n = 9; [c]n = 10; otherwise n = 12 for initial rating and n = 11 for final rating.

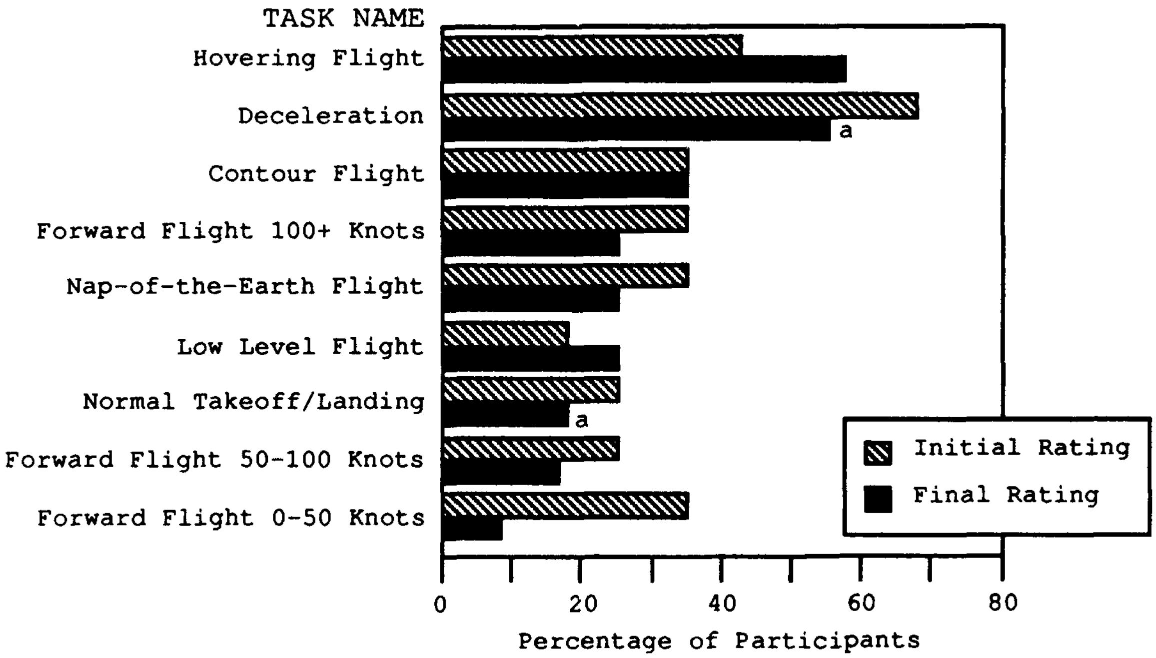
Figure 7. Percentage of participants who judged the field of view inadequate during the initial and final ratings.

deceleration. About 55% of the participants judged lateral FOV inadequate for performing threat detection and avoidance. Between 45% and 55% of the participants judged lateral FOV inadequate for forward flight at speeds greater than 50 knots and for NOE flight. No more than 36% judged lateral FOV inadequate for the remaining seven tasks.

Although not shown in Figure 7, there was no task for which more than 20% of the participants rated lateral FOV higher than 3 (just adequate enough) on the final rating; only 16% of all final ratings were larger than 3. Hence, even when a relatively large percentage of participants judged lateral FOV to be adequate for performing a task, they seldom judged it to be more than marginally adequate.

Visual cues and visual scene (general). Item 2 on Q1 required participants to assess the adequacy of the visual cues provided by the extra-cockpit display for nine tasks. The results of the initial and final ratings of visual cue adequacy are summarized in Figure 8. For all tasks except three (hovering, contour flight, and low level flight), a larger percentage of participants judged visual cues to be inadequate on the initial than on the final rating. However, because none of the differences between initial and final ratings were statistically significant, it cannot be concluded that the judged adequacy of visual cues increases with experience in AIRNET.

An examination of the final judgments shows that there are only three tasks for which one-third or more of the participants judged visual cues to be inadequate: 58% for hovering, 55% for deceleration, and 33% for contour flight. For the remaining six tasks, no more than 25% of the participants judged visual cues to be inadequate. As was



[a]n = 11; all other ns = 12.

Figure 8. Percentage of participants who judged the visual cues in the scene inadequate during the initial and final ratings.

true for lateral FOV, the judged inadequacy of visual cues for performing decelerations may be inflated by the difficulty encountered in performing decelerations in AIRNET.

Item 5 on Q1 required participants to rate the adequacy of the visual scene for performing tasks during a gunnery operation. About 75% of the participants judged the visual scene to be inadequate for situation awareness and target acquisition. For all other tasks, however, no more than 25% of the participants judged the visual scene to be inadequate.

The similarity of the responses to the items on visual cues (general) and visual scene (general) suggests that participants were responding to much the same attributes when responding to the two items. When considered together, the responses to the two items indicate that a clear majority of participants consider the visual scene and the cues therein to be inadequate for situation awareness, target acquisition, hovering, and deceleration. For all other tasks assessed, the visual scene and cues were judged inadequate by one-third or fewer participants.

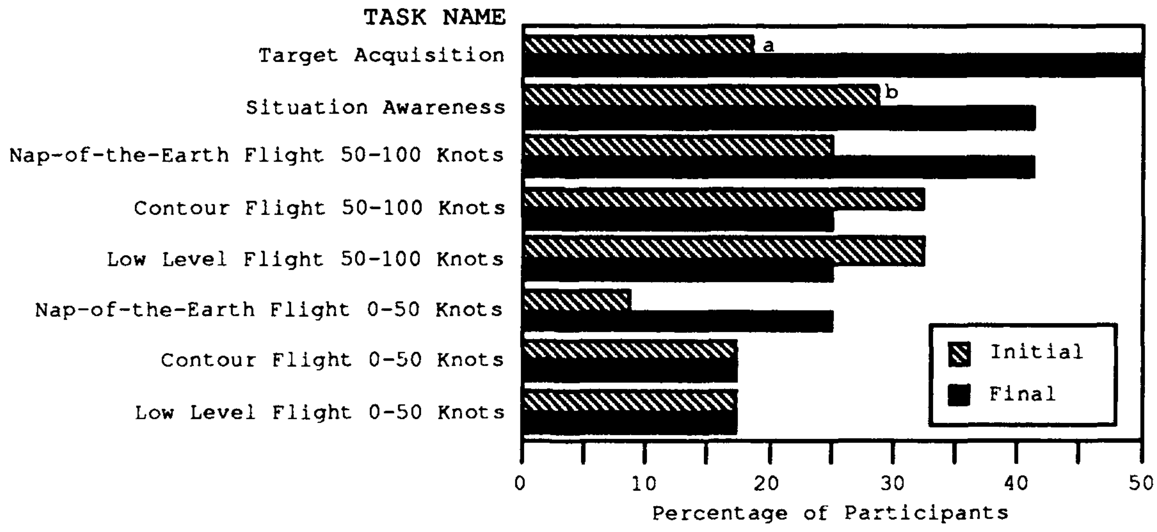
Stability and smoothness of visual scene. Participants rated the adequacy of the stability and smoothness of the visual scene for performing four tasks. Stability was rated only on Q1 (Item 3) and smoothness was rated only on Q2 (Item 4). The data show that the ratings were highly similar for stability and smoothness and were highly consistent across tasks. There was no task for which more than 25% of the participants judged stability to be inadequate; the range of percentage values varied from 17% to 25%. Similarly, there was no task for which more than about 30% of participants judged smoothness to be inadequate. These data provide no indication that either the stability or the smoothness of the AIRNET extra-cockpit display seriously degrades performance on any task investigated.

Realism of visual scene. Item 3 on Q2 required participants to rate the adequacy of the visual scene realism for four tasks: altitude detection, adjusting artillery fire, calling for artillery fire, and navigation. The item did not require participants to assess visual scene realism with respect to the real world; rather, they were asked to indicate whether or not the scene was sufficiently realistic to perform prescribed tasks.

The data show that more than one-half of the participants judged scene realism to be inadequate for three tasks: altitude detection (67%), adjusting artillery fire (60%), and calling for artillery fire (53%). In contrast, only 27% of the participants judged visual scene realism to

be inadequate for navigation. Although the AIRNET visual scene is not realistic in an absolute sense, most of the participants judged it to be adequate for the navigation that must be accomplished during a team training scenario. These data suggest that increased scene realism would improve performance on three of the four tasks included on the questionnaire. Additional research is required to specify the scene elements that should be modified and the manner in which they should be modified to achieve sufficient scene realism.

Discernibility and realism of topographic features. Participants were required to rate the discernibility of the topographic features portrayed on the extra-cockpit display (Q1, Item 4). Participants were told that the term discernibility refers to the ease with which a feature can be recognized and differentiated from other features when it is clearly visible. The results of the ratings of discernibility are shown in Figure 9. Examination of the final ratings shows that there are only three tasks for which more than 40% of the participants judged AIRNET topographic features to be inadequately discernible: target acquisition (50%), situation awareness (42%), and NOE flight 50 - 100 knots (42%). For all the other tasks, no more than 25% of



[a]$\underline{n}$ = 6; [b]$\underline{n}$ = 7; all other $\underline{n}$s = 12.

Figure 9. Percentage of participants who judged the topographic features to be inadequately discernible during the initial and final ratings.

the participants judged topographic feature discernibility to be inadequate on the final rating. Although there are some relatively large differences between initial and final ratings, none of the differences are statistically significant.

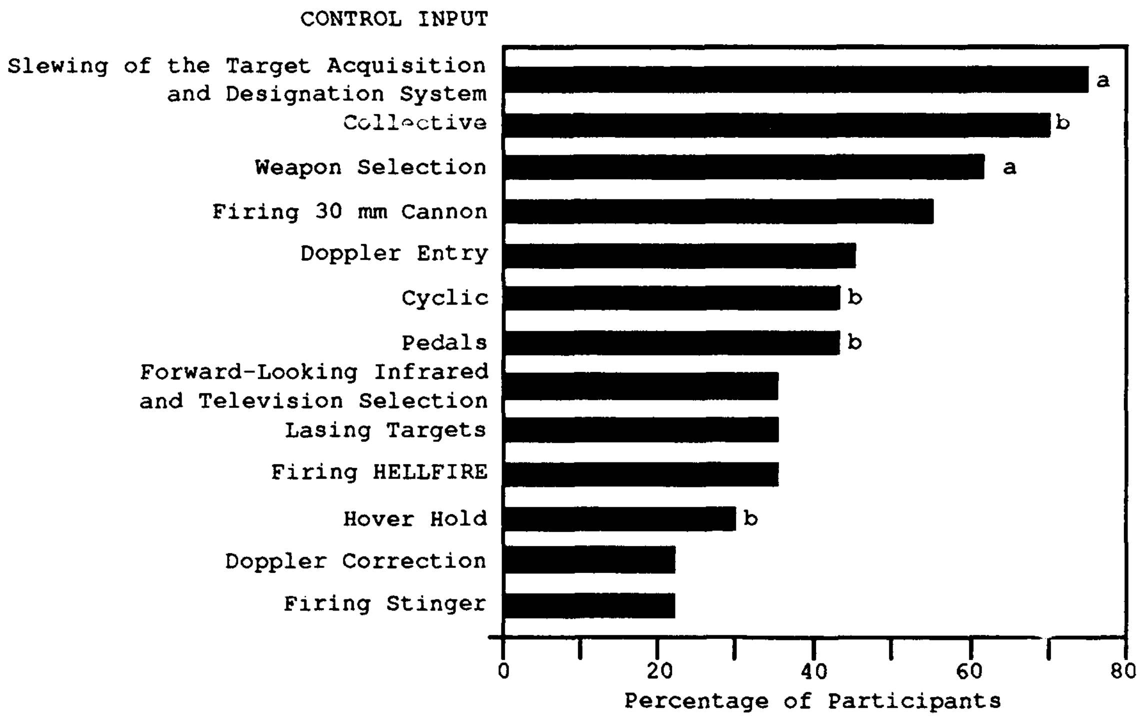
For tasks common to both items, the ratings of topographic feature realism (Q2, Item 5) are nearly identical to the ratings of visual scene realism (Q1, Item 4). A relatively high percentage of participants judged both scene and topographic feature realism inadequate for altitude detection (53% scene and 64% topographic feature). Conversely, a relatively low percentage judged scene and topographic feature realism inadequate for navigation (21% scene and 27% topographic feature). Other tasks for which the adequacy of topographic feature realism was rated include NOE flight and masking/unmasking. The percentage of participants who judged topographic feature realism to be inadequate for NOE flight and masking/unmasking are 43% and 35%, respectively.

Vision problems. Item 20 on Q2 required crewmembers to rate the adequacy of the visual system with respect to its propensity for producing eye fatigue, eye strain, and blurred vision. One-half the crewmembers rated the visual system inadequate with respect to eye strain; 43% rated the visual system inadequate with respect to eye fatigue. Only 29% rated the visual system inadequate with respect to blurred vision.

Judged Adequacy of Flight Characteristics

Three questionnaire items were designed to assess crewmembers' judgments about the adequacy of the simulated aircraft's flight characteristics. Item 8 on Q1 asked crewmembers to judge whether the simulated aircraft flies enough like a helicopter to enable them to perform their mission. All crewmembers rated the aircraft simulation inadequate on the initial rating; 89% rated the simulation inadequate on the final rating. Item 9 on Q1 asked crewmembers to judge the extent to which the simulated aircraft imposes realistic attentional demands on the pilot. The simulated aircraft was judged inadequate with respect to attentional demands by 90% of the crewmembers on the initial rating and 71% of the crewmembers on the final rating.

Item 1 on Q2 asked crewmembers to rate the realism of AIRNET's response to a variety of control inputs; crewmembers' responses to this item are summarized in Figure 10. The horizontal bars in Figure 10 show the percentage of



[a]$\underline{n}$ = 8; [b]$\underline{n}$ = 7; all other $\underline{n}$s = 9.

Figure 10. Percentage of participants who judged the realism of AIRNET's response to control inputs to be inadequate.

crewmembers who judged the associated control response to be inadequate. Examine first the crewmembers' judgments about the three primary flight controls: the collective, cyclic, and pedals. Approximately 71% of the crewmembers judged the response to collective inputs to be inadequate and about 43% judged the response to cyclic and pedal inputs to be inadequate. These ratings provide further support for the conclusion that the AIRNET aircraft simulation lacks sufficient realism.

Other control inputs judged inadequate by more than 40% of the crewmembers include TADS slewing (75%), weapon selection (63%), 30 mm cannon firing (56%), and Doppler entry (44%). Performance on tasks that require the use of these controls is probably degraded by the lack of realism in AIRNET's response to control inputs. The remaining control inputs listed in Figure 10 were judged inadequate by one-third or fewer of the participants, so they are not considered to be a serious problem.

Judged Comfort of the Crew Station

Crewmembers were asked to rate the comfort of prescribed attributes of the crew station (Item 19, Q2). Only three attributes were judged inadequate by more than one-third of the crewmembers: height of the visual screens (50%), distance of screens from instruments (43%), and location of the instrument displays (43%). About one-third of the crewmembers judged the comfort of the seats to be inadequate for training sessions of 2 hours or more. The distance of the screens from the pilot was judged inadequate (excessive) by only 30% of the crewmembers. The location of the collective and the orientation of the pedals were judged inadequate by fewer than 10% of the crewmembers.

Although these results indicate that selective cockpit design modifications might improve user comfort, it cannot be inferred from these data that such improvements would result in measurable improvements in AIRNET's training effectiveness.

Adequacy of Communication System

Items on Q1 asked crewmembers to rate the adequacy of the AIRNET communication system for information transmission (Item 11), information reception (Item 12), and monitoring two channels simultaneously (Item 13). The ratings on all three items were highly similar on both the initial and the final rating. On the final rating, between 42% and 58% of the crewmembers judged the communication system to be inadequate. The ratings of the communication system did not differ significantly as a function of type communication (transmission vs reception) or communication function (other crewmember, other aircraft, or TOC commander). Discussions with crewmembers indicated that the main reason for the inadequate rating of the communication system is that it provides too few communication channels.

Judged Maximum Target Acquisition Range

Items on Q1 asked crewmembers to judge the maximum range at which the AIRNET visual system supports unaided target acquisition (Item 6) and target acquisition with FLIR (Item 7). On the final administration of Q1, crewmembers' judgments corresponded closely with their performance on the target detection performance assessment. For unaided viewing, 83% of the crewmembers indicated that the maximum target acquisition range is 1,000 m or less; only one crewmember indicated that the maximum target acquisition

range exceeds 1,500 m. For FLIR viewing, 75% of the crewmembers indicated that the maximum target acquisition range is 4,000 m or less; no one indicated that the maximum target acquisition range with FLIR is greater than 5,000 m.

Judged Training Value of AIRNET

All participants used a 5-point rating scale to rate the value of AIRNET, in its current configuration, for training each of 25 tasks (Item 24, Q2). The rating values selected for each task were summed across the 15 raters, and the resulting values were used to rank order the tasks. Table 7 shows the rank-ordered listing of tasks along with the ranking for each task. The tasks with the highest ranking (smallest rank number) are the ones for which AIRNET was judged to have the greatest training value.

As would be expected, AIRNET's training value tends to be rated highest for collective tasks that require close coordination between two aircraft crews or between an aircraft crew and the crew of a ground unit. For example, collective tasks for which AIRNET's training value is rated relatively high (among the 10 highest ranked tasks) include close air support, tactics planning and briefing, call for artillery fire, adjusting artillery fire, target handover, low altitude tactics, high threat tactics, and low threat tactics.

It seems probable that limitations of the visual system contributed to the low ranking of some tasks. For instance, a limited FOV may have contributed to the low ranking for tasks such as two-ship tactics, four-ship tactics, and tactical formation. Similarly, the limited target detection and identification range may have contributed to the low ranking for such tasks as gun employment, target engagement, and visual identification.

Although the data in Table 7 are useful for assessing the *relative* value of AIRNET for training different tasks, the reader is cautioned against assuming that such data are a reliable indicator of the *absolute* training value of AIRNET.

Table 7

Training Tasks Rank Ordered by Rated Training Value of AIRNET (N = 25)

Task name	Sum of ratings	Rank
Close air support	41	1
Tactics planning and briefing	40	2
Call for artillery fire	38	3
Adjusting artillery fire	37	4.5
Target handover	37	4.5
Low altitude tactics	36	6
High threat tactics	35	7
Low level flight	34	8.5
Low threat tactics	34	8.5
Safe passage	33	10
Medium/high altitude tactics	31	12.5
Movement to contact	31	12.5
Screening operations	31	12.5
Tactical intercept	31	12.5
Egress tactics	30	16.5
Missile employment	30	16.5
Reconnaissance missions	30	16.5
Two-ship tactics	30	16.5
Four-ship tactics	29	20
Gun employment	29	20
Nap-of-the-earth flight	29	20
Communication procedure	27	22
Target engagement	26	23
Tactical formation	24	24.5
Visual identification	24	24.5

Discussion and Conclusions

This research was designed principally to assess experienced crewmembers' ability to perform individual and collective tasks in AIRNET. The fundamental premise underlying the research is that useful, albeit limited, inferences about AIRNET's training value can be drawn from data on experienced aviators' ability to perform selected tasks in AIRNET. Specifically, it is assumed that if a task that an experienced aviator performs routinely in the aircraft cannot be performed adequately by the aviator in AIRNET, it is unlikely that effective training on that task can be accomplished in AIRNET. The research was also designed to identify AIRNET design attributes that contribute to crewmembers' inability to perform key tasks in the device. Finally, the research was designed to assess participants' opinions about AIRNET's effectiveness for training specific flying tasks.

The methodology employed yielded two types of data: performance and opinion. Crewmembers' ability to perform selected individual and collective tasks was assessed by highly experienced SMEs (instructor pilots). The SMEs assessed crewmembers' ability to perform 13 individual flying tasks in AIRNET and assessed the maximum range at which crewmembers can detect and identify targets in AIRNET. Performance on collective tasks and subtasks was assessed by SMEs in the context of tactically and doctrinally valid scenarios for each of three types of missions for light-attack and heavy-attack helicopter teams: a cross-FLOT deliberate air attack, a deliberate offensive attack, and a hasty attack.

Participants' (crewmembers and SMEs) opinions were assessed by means of questionnaires that were administered at three points during the evaluation period. The questionnaires included items that required participants to (a) rate the adequacy of specific AIRNET components for performing specified tasks, (b) rate the maximum range at which targets can be detected (unaided and FLIR), (c) identify the physiological discomfort and simulator sickness symptoms experienced in AIRNET, and (d) rate the probable training effectiveness of AIRNET. In addition, participants were requested to identify AIRNET system components that, in their judgments, contributed to inadequate performance of collective tasks. All crewmembers and SMEs were requested to make such judgments during the collective task assessment sessions. However, because participants often failed to record their judgments during the evaluation sessions, two SMEs subsequently made judgments about AIRNET components that

contributed to inadequate performance for each of 35 (collective) subtasks.

The composite research findings are discussed below as they bear on the following questions.

- Of the tasks investigated, what tasks can and what tasks cannot be performed adequately in AIRNET by experienced crewmembers?
- When certain tasks cannot be performed adequately in AIRNET, what inferences can be drawn from these findings about the probable training effectiveness of AIRNET?
- What AIRNET components contribute to the inadequate performance of tasks and how must these components be modified to provide for adequate performance?

Individual Flying Tasks

The results of the assessment of individual flying task performance indicate that, with sufficient practice, crewmembers can adequately perform most of the individual tasks investigated, including hovering flight, accelerations, navigation at various speeds, low level flight, contour flight, and NOE flight. However, four tasks could not be performed adequately even after substantial experience in AIRNET: vertical masking, lateral masking, normal deceleration, and NOE deceleration. Inadequate performance on these four tasks, particularly decelerations, is unlikely to be overcome with a reasonable amount of practice in AIRNET.

It can be argued that, since AIRNET was not developed to teach aviators to perform individual flying tasks, the ease or difficulty of performing individual flying tasks has little bearing on AIRNET's effectiveness for training collective tasks. There are at least two reasons why this argument is not valid. First, difficulty in performing individual flying tasks may seriously degrade the efficiency of training collective tasks. A crash during a team training exercise delays training for the entire team and, more importantly, interferes with the continuity and flow of the exercise. Even if crashes are not frequent, difficulty in performing individual flying tasks may create unrealistically high workload that, in turn, prevents crewmembers from attending to the collective tasks for which AIRNET was designed to train. Second, excessive difficulty in performing individual flying tasks may adversely affect trainees' and trainers' judgments about AIRNET's utility for

training collective tasks. Negative attitudes about a device's training effectiveness are certain to have a negative influence on the frequency and effectiveness with which the device is used.

These arguments are particularly germane for the individual tasks that crewmembers had the most difficulty performing in AIRNET. Masking (lateral and vertical) and decelerations (normal and NOE) are tasks that must be performed frequently in nearly any attack team training scenario; furthermore, they are tasks for which crash likelihood is high. For these reasons, the authors believe that AIRNET's training effectiveness is significantly degraded by the difficulty associated with performing masking and deceleration tasks. Furthermore, spontaneous comments and questionnaire responses by crewmembers suggest that AIRNET's training effectiveness also may be degraded by the excessive amount of effort that must be expended to perform some of the individual flying tasks that crewmembers can, in fact, learn to perform to standards in AIRNET. Crewmember comments and questionnaire responses suggest that excessive effort may be required to perform hovering, contour flight, NOE flight, and high speed forward flight tasks.

The evidence indicates that the difficulty in performing individual tasks stems mainly from the aircraft equations of motion employed in AIRNET. On one questionnaire item (Q1, Item 8), 89% of the crewmembers rated AIRNET inadequate with respect to the extent that it flies like a helicopter. On another item (Q1, Item 9), 71% of the crewmembers indicated that AIRNET imposes unrealistically high attentional demands on the person flying it. In a third item (Q2, Item 1), a large proportion of the crewmembers indicated that AIRNET's responses to cyclic inputs, collective inputs, and pedal inputs are not sufficiently realistic; 71% judged collective responses to be inadequate and 43% judged cyclic and pedal responses to be inadequate. Responses to questionnaire items about the visual system indicate that the limited FOV and scene content contributed to difficulty in performing some individual flying tasks, especially decelerations, hovering, NOE flight, and contour flight.

The composite results from the individual task assessment support the conclusions that (a) AIRNET's training effectiveness is degraded by the difficulty associated with performing some individual flying tasks and (b) improved equations of motion is an essential first step in improving AIRNET's performance. The results also suggest that performance benefits may be realized from a wider FOV and a more realistic scene content.

Target Detection and Identification Range

Target detection and identification is an essential part of any useful attack team training scenario. As a consequence, the training effectiveness of any device intended for attack team training is certain to be influenced by the range at which targets can be detected and identified. The results of the assessment of target detection and identification performance leave no doubt that the maximum target detection and identification range with unaided vision is less in AIRNET than is possible in an aircraft under good visibility conditions However, the key question is whether unaided target detection and identification range is great enough to support effective training.

The data indicate that, with unaided vision, reliable target detection in AIRNET cannot be expected at ranges beyond about 1,500 m. Even though identification of a target as friend or foe in AIRNET requires only a color discrimination, maximum (unaided) IFF range is less than maximum target detection range. The maximum range for unaided identification of specific targets (tank, truck, etc.) in AIRNET is considerably less than maximum IFF range.

The maximum unaided target detection and identification range in an aircraft varies as a function of lighting conditions, atmospheric attenuation (dust, smoke, or water particles), and visual obstructions (terrain relief, vegetation, and cultural features). Hence, it is difficult to specify a single range to use as a standard for evaluating AIRNET. For purposes of this discussion, it is assumed that effective training would be possible in AIRNET if (a) unaided target detection can be accomplished reliably at a range of about 3,500 m, (b) unaided IFF can be accomplished at a range of about 2,500 m, and (c) unaided identification of a specific target type can be accomplished at a range of about 1,500 m.[4] These ranges far exceed the maximum target detection and identification (unaided) ranges in AIRNET. As a consequence, the authors conclude that AIRNET's training value is diminished substantially by the limited target detection and identification range.

Target detection with the AIRNET FLIR can be accomplished reliably at ranges to 6,000 m. IFF identification can be accomplished with high (but not 100%)

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[4]The assumptions about ranges to use as standards for AIRNET are based on information gained during informal discussions with Army aviators; however, they do not reflect the official judgment of any Army agency.

reliability to a range of about 4,000 m. The range at which specific targets can be identified reliably with FLIR is less. Although all targets were correctly identified at a range of 1,000 m, only one-half of the targets were correctly identified at ranges between 2,000 and 4,000 m, and none were correctly identified at ranges greater than 4,000 m.

As was true for unaided vision, the maximum target detection and identification range with an operational FLIR varies with conditions. Discussions with Army aviators indicated that, under near optimal conditions and with magnification, targets can be detected to a range of 8,000 m and can be identified (specific target type) at a range of 6,500 m.

The authors believe that target detection range with the AIRNET FLIR is probably great enough to support effective training. However, target identification range (IFF and specific) with AIRNET FLIR is probably <u>not</u> great enough to support effective training.

The research produced other data that bear on the adequacy of target detection and identification ranges in AIRNET. Inadequate target acquisition range was identified in both the collective task assessment and the post hoc assessment as a factor that contributed to the inadequate performance of collective tasks. Inadequate target acquisition range was the most frequently identified factor in the post hoc assessment and the fourth most frequently identified factor during the collective task assessment. Responses to one questionnaire item (Q1, Item 4) indicated that 50% of the crewmembers judged that the visual system's discernibility was inadequate to support target acquisition. Finally, crewmembers judged the training value of AIRNET to be lower for visual identification than for any other task investigated (see Q2, Item 24).

The composite results described above and in previous sections of the report support the conclusion that AIRNET's training effectiveness is degraded by (a) the limited range at which targets can be detected and identified with unaided vision and (b) the limited range at which specific targets can be identified with the AIRNET FLIR. Target detection and IFF identification range with AIRNET FLIR appear adequate to support effective training.

Collective Task Performance

The results of the collective task performance assessment are more difficult to interpret than the results

of the assessment of performance on either individual flying tasks or target detection and identification. The difficulty stems primarily from inconsistencies in the collective task performance ratings. On the one hand, there were few collective subtasks for which performance was judged inadequate by a large proportion of crewmembers, SMEs, or both. On the other hand, there are at least four reasons to believe that performance on collective tasks was, in fact, inadequate for more of the tasks than was indicated by the performance ratings.

First, there were 35 collective subtasks for which performance was judged inadequate on two or more iterations (by two crews, two SMEs, or one of each). These findings show that there are a substantial number of collective subtasks for which performance was not consistently judged adequate. Second, performance on many collective subtasks was judged adequate even though the collective subtasks require crewmembers to perform individual flying tasks that clearly cannot be performed to standards in AIRNET. The most conspicuous examples include adequate ratings on the performance of collective subtasks that require crewmembers to perform decelerations and target detection and identification. Third, the SMEs who performed the post hoc assessment agreed that the 35 collective subtasks identified as problem subtasks cannot consistently be performed adequately in AIRNET; moreover, they had no difficulty identifying AIRNET components that contributed to the performance difficulty.

Finally, the researchers observed inconsistencies between the collective task performance ratings and the spontaneous comments of crewmembers and SMEs. After observing the collective task performance and hearing crewmember complaints about the difficulty in performing some of the collective tasks, the researchers expected far more inadequate ratings than were found. For these four reasons, the authors have concluded that the rating data represent an underestimate of the frequency with which collective tasks were performed inadequately in AIRNET.

An examination of the 35 collective subtasks identified as problem subtasks (see Table 5) and the results of the SME post hoc assessment suggest that problems in performing collective subtasks stem mainly from difficulty in controlling the simulated aircraft and difficulty in seeing (unaided and FLIR) what must be seen to perform certain collective subtasks effectively. For instance, the results of the post hoc assessment showed that the four most frequent contributors to inadequate performance of collective subtasks are either aircraft control problems (control during terrain

flight and decelerations) or vision problems (limited target detection/identification range and limited FOV). The results also indicate that performance on some collective subtasks is adversely affected by the sparseness of the topography in the visual system's topographic data base. Excessively sparse topography degraded performance on such tasks as deployment to cover, masking, employing suppressive fire, firing weapons at maximum ranges, and performing SAR. Table 6 and the supporting discussion provide more information about the specific subtasks adversely affected by each of the AIRNET component design shortcomings.

Because an important objective of this research was to identify ways in which AIRNET's training effectiveness may be increased, much of the description and discussion of results necessarily have focused on actual or potential shortcomings in the design of AIRNET components. However, it is equally important that readers have a clear understanding of AIRNET's strengths. In this regard, it is important to emphasize that the composite data revealed few instances in which AIRNET lacked the capability that trainers need to create and implement a tactically valid attack team training scenario. The only important capabilities that participants judged to be lacking in AIRNET are the lack of a remote designation capability and the lack of an ATHS capability.

The composite results of the collective task assessment support the following conclusions.

- Crewmembers encounter problems in performing a substantial number of collective subtasks. The problems stem mainly from difficulty in controlling the simulated aircraft and difficulty in seeing (unaided and FLIR) what must be seen to perform collective subtasks effectively.

- The specific AIRNET component design shortcomings that degrade performance on collective tasks are limited target acquisition range, limited lateral FOV, aircraft control difficulties (especially during terrain flight, deceleration, and weapons firing), and excessively sparse and/or unrealistic topographic features.

- With few exceptions, AIRNET has the fundamental capabilities needed to develop and implement tactically valid training scenarios for Army aviation attack teams. Remote target designation and ATHS are the only important capabilities that are lacking in the current version of AIRNET.

Questionnaire Results

The questionnaires employed in this research were designed to assess participants' judgments about (a) the adequacy of AIRNET components for performing specific tasks, (b) the range at which targets can be acquired in AIRNET (unaided and FLIR), and (c) the probable effectiveness of AIRNET for training specific tasks. Since participants were required to rate the adequacy of AIRNET components for performing specific tasks, the responses provide opinion data on both AIRNET component adequacy and problem tasks. That is, if a large proportion of participants judge a component to be inadequate for performing a specific task, it can be inferred that the task cannot be performed adequately and the AIRNET component in question contributes to the inadequate performance.

The following discussion reflects the authors' best judgments about whether the crewmembers' responses to questionnaire items indicate the presence of an AIRNET component design shortcoming that is important enough to adversely affect crewmembers' judgments about AIRNET's training value. In general, the authors have judged that a potentially important problem exists if 40% or more of the crewmembers judged an AIRNET component to be inadequate for performing one or more tasks. It is recognized that some readers may use different criteria for defining a problem. For this reason, readers are encouraged to examine carefully the questionnaire results presented in the previous section of the report and to draw their own inferences about the presence and severity of AIRNET component design shortcomings and the extent to which the shortcomings are likely to influence trainees' perceptions of AIRNET's training value.

Responses to questionnaire items that address AIRNET component design indicate that the components most often rated inadequate are the visual system and the simulated aircraft's flight characteristics. Taken as a whole, crewmembers' responses about the adequacy of the visual system reflect the opinion that the lateral FOV is too small and that the computer generated visual scene is not sufficiently realistic. The data show that crewmembers believe that the limited FOV and the unrealistic visual scene degrade performance on many, but by no means all, of the tasks investigated. In addition, many crewmembers indicated that the visual system creates eye fatigue (50%), eye strain (43%), and blurred vision (29%). Although these results cannot be assumed unimportant, this research yielded no data with which to judge whether the frequency and severity of these visual symptoms are great enough to degrade training effectiveness. Finally, the questionnaire data indicate that

a substantial proportion of the crewmembers believe that the visual displays are positioned too high and too far from the crewmember. The questionnaire data did not indicate a problem in either the stability or smoothness of the visual system.

Responses to questionnaire items that address AIRNET's flight characteristics clearly indicate that crewmembers consider AIRNET's equations of motion to be inadequate for performing a substantial number of important flying task. These results are entirely consistent with the results of the assessments of both individual and collective task performance. The questionnaire results also indicate that a substantial percentage of crewmembers consider AIRNET inadequate in its responses to the control inputs required to perform TADS slewing, weapons selection, 30 mm cannon firing, and doppler entry.

Other AIRNET components or design attributes judged inadequate by many crewmembers include its communication system, the positioning of the cockpit instrument displays, and the comfort of the seats. Discussions with crewmembers indicated that the communication system was judged inadequate mainly because the controls are difficult to operate and the system has too few communication channels. Discussions with crewmembers failed to reveal any consistent opinions about the manner in which the cockpit instrument displays should be repositioned.

Crewmembers' ratings of AIRNET's training value provide useful information about the _relative_ value of AIRNET for training different tasks. However, as was stated earlier, readers are cautioned against using such data to draw inferences about the _absolute_ training value of AIRNET. The results show that AIRNET's training value tends to be rated highest for collective tasks--the tasks that AIRNET was designed to train. When AIRNET's training value was rated low for a collective task, it appears that the low ratings stem from shortcomings in one or more of AIRNET's components rather than from a lack of capability to simulate tactically valid training scenarios.

In general, the questionnaire data support all of the conclusions drawn from the assessment of individual task performance, target detection and identification performance, and collective task performance. The questionnaire data support the conclusion that Army aviators' judgments about the training value of AIRNET are likely to be adversely affected by what they perceive to be shortcomings in the design of certain AIRNET components.

Recommendations

The results of this research provide evidence that shortcomings in the design of certain AIRNET components have an adverse effect on the performance of many of the tasks that must be performed to accomplish team training in AIRNET. Moreover, the results indicate that the same design shortcomings may have an adverse effect on crewmembers' perceptions of AIRNET's training value. The results do not provide the data with which to estimate the extent to which AIRNET's training value is degraded by these shortcoming or, conversely, the extent to which AIRNET's training value would be increased by the many alternative modifications that are possible for improving the components found to be lacking. Only transfer-of-training research can provide the data needed to make such judgments. Even so, the results of this research are sufficiently compelling to justify recommendations to evaluate the cost and feasibility of alternative modifications that may eliminate or reduce the AIRNET component design shortcomings found to adversely affect performance, crewmembers' attitudes about training effectiveness, or both.

The recommendation considered to have the highest priority is to perform analytical research to identify alternative methods for improving the flight characteristics of the simulated aircraft and estimate the cost and benefits of promising alternatives. The suitability of equations of motion developed for other helicopter simulators should be assessed before attempts are made to develop new ones. An analytical assessment by experts in helicopter simulation should be adequate to identify existing equations of motion that will support the tasks that must be performed in AIRNET. If so, the key task is to determine whether suitable equations of motion can be implemented on AIRNET's existing computers or affordable computers with enhanced capabilities.

The recommendation with the second highest priority is to identify and evaluate alternative methods for increasing the range at which targets can be detected and identified with unaided vision and with FLIR. Although the target detection range with the AIRNET FLIR may be adequate for training, some increase in training realism may result from increasing the range by 1 or 2 km. Increasing the visual system's resolution is likely to be an excessively costly way to increase target acquisition range. Hence, it appears worthwhile to consider alternative techniques such as increasing the absolute size of targets or making target size variable and inversely related to viewing range. In considering such alternatives, it should be kept in mind that AIRNET is not intended to teach target detection and

identification skills. Rather, target detection and identification in AIRNET should be viewed as a prerequisite for performing effective training on many of the collective tasks.

A third recommendation is to identify and evaluate alternative methods for increasing the realism of the visual system's scene elements. This effort should begin with a compilation of additional information about the scene elements that contribute to inadequate performance of key tasks. The present results provide some information about scene elements that were judged too unrealistic, but the research was not designed to provide comprehensive information about the adequacy of scene element realism. Once the requirements for increased realism are better understood, methods can be identified to meet these requirements by modifying the AIRNET topographic data base and the existing visual system and replacing the existing visual system with one that has more capability.

A fourth recommendation is to identify and evaluate alternative methods for increasing the lateral FOV of the visual system. This effort should begin by obtaining additional information about (a) the full range of tasks for which performance is adversely affected by a limited lateral FOV and (b) the amount that the FOV would need to be increased to support adequate performance of these tasks. Since increasing the actual FOV of a visual system is certain to be costly, methods should be considered for increasing the _functional_ FOV without increasing the _actual_ FOV. For instance, it may be possible to use auditory or symbolic information to advise aviators of the presence or location of important objects that are visible from an aircraft cockpit but are located beyond the limits of AIRNET's visual system.

Finally, it is recommended that methods be identified and evaluated for (a) improving the communication system's controls and increasing the number of communication channels; (b) improving the positioning of the visual system displays and the cockpit instrument panel; (c) improving AIRNET's response to control inputs for TADS slewing, weapon selection, 30 mm cannon firing, and doppler entry; and (d) improving the comfort of the seats in the operator stations. Although it seems unlikely that such improvements would result in major improvements in AIRNET's training effectiveness, they may have a significant effect on AIRNET's user acceptance.

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A P P E N D I X A

LISTING OF COLLECTIVE TASKS AND SUBTASKS INVESTIGATED FOR SCOUT CREWMEMBERS AND ATTACK CREWMEMBERS

SCOUT HELICOPTER TASKS/SUBTASKS

Conduct Movement to a Holding Area

- Move to a holding area
- Conduct passage of lines
- Unit arrives at the holding area

Use Passive Air Defense Measures

- Company utilizes passive air defense measures while en route

Conduct Tactical Air Movement as Part of a Movement to Contact or an Air Assault Security

- Company conducts movement
- Conduct passage of lines

Move to and Occupy a Battle Position

- Reconnoiter the battle position
- Occupy the battle position
- Perform actions on contact
- Depart the battle position

Use Countermeasures Against Enemy Air Defense Artillery (ADA) to Ensure Aircraft Survivability

- Aircrews use terrain flight techniques and passive ADA countermeasures in accordance with the factors of mission, enemy, terrain, troops, and time available (METT-T)

Report Intelligence Data

- Scout/weapons team leader or platoon leaders submit spot report
- Scout/weapons team leader or platoon leaders report bombing, shelling and mortar, rocket and aircraft fire
- Scout/weapons team leader or platoon leaders submit battle damage assessment reports

Establish Contact

- Lead elements react to initial contact with opposing forces (OPFOR)
- Perform actions on contact

Engage Targets

- Conduct target handovers
- Employ close air support
- Call for and adjust artillery fire

Conduct Hasty Air Combat Operations

- Company commander issues the operations order, designates air combat teams, reviews aircrew standing operating procedures (SOP)

Return to Assembly Area and Prepare for Future Operations

- Company conducts forward arming and refueling point (FARP) operations
- Company commander orders the company to depart the rally point
- Company reorganizes at the forward assembly area

Move From a Battle Position

- Execute new mission guidance

Conduct Joint Air Attack Team (JAAT) Operations

- Unit conducts JAAT operation

Conduct Downed Aircrew Recovery

Conduct Deliberate Air Attack

ATTACK HELICOPTER TASKS/SUBTASKS

Conduct Movement to Holding Area

- Move to the holding area
- Conduct passage of lines
- Unit arrives at the holding area

Use Passive Air Defense Measures

- Company utilizes passive air defense measures while en route

Move to and Occupy a Battle Position

- Occupy battle position

Use Countermeasures Against Enemy to Ensure ADA Aircraft Survivability

- Aircrews use terrain flight techniques and passive ADA countermeasures in accordance with the factors of METT-T

Report Intelligence Data

- Scout/weapons team leader or platoon leaders submit spot report
- Scout/weapons team leader or platoon leaders report bombing, shelling and mortar, rocket and aircraft fire
- Scout/weapons team leader or platoon leaders submit battle damage assessment reports

Establish Contact

- Lead elements react to initial contact with OPFOR

Engage Targets

- Attack platoons engage targets

Conduct Deliberate Air Attack

Conduct Hasty Air Attack

- Company commander issues the operations order, designates air combat teams, reviews aircrew SOP

Return to Assembly Area and Prepare for Future Operations

- Company conducts FARP operations
- Company commander orders the company to depart the rally point
- Company reorganizes at the forward assembly area

Move from a Battle Position

- Depart the battle position
- Execute new mission guidance

Conduct JAAT Operations

- Company commander coordinates close air support assets
- Company commander and platoon leaders conduct fire support coordination
- Unit conducts JAAT operations

Conduct Downed Aircrew Recovery

A P P E N D I X   B

SPECIMENS OF RATING FORMS USED TO ASSESS COLLECTIVE TASKS

ENGAGE TARGETS (TASK 01-2-0105)

ATTACK PLATOONS ENGAGE TARGETS

GO /	NO	GO	N/A	
	P	S		- Engagement Priority
	P	S		- Target Priority
	P	S		- Maximum Standoff Range (METT-T Dependent) and Optimal Direction of Attack
	P	S		- Fire Distribution Plan
	P	S		- Procedural Control Measures
	P	S		- Alternate/Supplemental Firing Positions
	P	S		- Running Fire if Applicable
	P	S		- OH-58D Rapid or Ripple Fires; Autonomous or Remote

GO / NO GO <u>ATTACK PLATOONS ENGAGE TARGETS</u>

COMMENTS: ____________________

____

____

SYSTEM	OVERALL PILOT SAT	OVERALL PILOT UNSAT
SAT		
UNSAT		

USE COUNTERMEASURES AGAINST ENEMY ADA TO ENSURE AIRCRAFT SURVIVABILITY (TASK 01-2-0301)

AIRCREWS USE TERRAIN FLIGHT TECHNIQUES AND PASSIVE ADA COUNTERMEASURES IAW THE FACTORS OF METT-T

GO /	NO	GO	N/A	
	P	S		- Use Terrain Flight to Mask Aircraft From Enemy Detection and Fire
	P	S		- Minimize Flights in Open Areas
	P	S		- Expedite Traversing From Open Terrain to Cover and Concealment
	P	S		- Mask Aircraft When Possible to Reduce Aircraft Exposure
	P	S		- Use Teamwork With Other Aircraft to Decoy Enemy ADA System During Fire and Maneuver
	P	S		- Engage All Enemy Targets at Maximum Standoff Range When Terrain Permits
	P	S		- Employ Actions on Enemy Contact and Proceed as Directed by Mission Briefing and SOP

GO / NO GO <u>AIRCREWS USE TERRAIN FLIGHT TECHNIQUES AND PASSIVE ADA COUNTERMEASURES IAW THE FACTORS OF METT-T</u>

COMMENTS:

	OVERALL PILOT SAT	OVERALL PILOT UNSAT
SYSTEM SAT		
SYSTEM UNSAT		

ENGAGE TARGETS (TASK 01-2-0105)

CONDUCT TARGET HANDOVERS

GO /	NO	GO	N/A	
☐	P	S	☐	- Identify Targets
☐	P	S	☐	- Handover Targets and Release Engagement Authority to Attack Helicopter --Provide Task Description --Task Location --Technique of Attack --Method of Control --Execution
☐	P	S	☐	- Continue to Identify Targets and Provide Flank and Rear Security to Attack Helicopters
☐	P	S	☐	- Maintain Contact With the Enemy

GO / NO GO <u>CONDUCT TARGET HANDOVERS</u>

COMMENTS:____

		OVERALL PILOT SAT	OVERALL PILOT UNSAT
SYSTEM	SAT		
SYSTEM	UNSAT		

CONDUCT A TACTICAL AIR MOVEMENT AS PART OF A MOVEMENT TO CONTACT OR AN AIR ASSAULT SECURITY (TASK 01-2-2104)

AIRCREWS USE TERRAIN FLIGHT TECHNIQUES AND PASSIVE ADA COUNTERMEASURES IAW THE FACTORS OF METT-T

GO	/ NO	GO	N/A	
	P	S		- Depart Current Location at Time Specified in Order
	P	S		- Employ Appropriate Movement Techniques IAW METT-T
	P	S		- Employ Terrain Flight Techniques IAW METT-T
	P	S		- Make Initial Contact With Smallest Force Possible (Light Platoon)
	P	S		- Conduct Reconn of Possible Enemy Avenues of Approach
	P	S		- Scout/Attack Units Employ Remote HELLFIRE Engagement Procedures to Protect Scouts During Movement
	P	S		- Observe Radio Communication Restrictions

GO / NO GO <u>AIRCREWS USE TERRAIN FLIGHT TECHNIQUES AND PASSIVE ADA COUNTERMEASURES IAW THE FACTORS OF METT-T</u>

COMMENTS: ______________________________

		OVERALL PILOT SAT	OVERALL PILOT UNSAT
SYSTEM	SAT		
SYSTEM	UNSAT		

A P P E N D I X   C

CREWMEMBER QUESTIONNAIRE (Q1)

Date________________

Name________________ Aircraft: Crewseat:

Scout__________ Pilot__________

Unit________________ Attack__________ Copilot__________

AIRNET RATING SCALE
Technical Performance Issues

Use the 5-point scale shown below to rate the technical performance of the AIRNET device. Circle the performance rating for each of the areas listed. Use the back of this page for additional comments if more space is required.

RATING SCALE

Totally inadequate	Somewhat inadequate	Just adequate enough	More than adequate	Much more than adequate
1	2	3	4	5

Visual Fidelity

OUT THE WINDOW FIELD OF VIEW:

1. Is the field of view wide enough to enable you to perform your mission?

Forward flight 0 to 50 knots	1	2	3	4	5
Forward flight 50 to 100 knots	1	2	3	4	5
Forward flight greater than 100 knots	1	2	3	4	5
Low level flight	1	2	3	4	5
Contour flight	1	2	3	4	5
NOE flight	1	2	3	4	5
Hovering	1	2	3	4	5
Deceleration	1	2	3	4	5
Normal take-off/landing	1	2	3	4	5
Threat detection/avoidance	1	2	3	4	5
Target acquisition	1	2	3	4	5
Situation awareness	1	2	3	4	5
Formation flight	1	2	3	4	5

Comments:____

RATING SCALE

Totally inadequate	Somewhat inadequate	Just adequate enough	More than adequate	Much more than adequate
1	2	3	4	5

2. Does the forward visual scene contain sufficient visual cues to perform the mission?

Forward flight 0 to 50 knots	1	2	3	4	5
Forward flight 50 to 100 knots	1	2	3	4	5
Forward flight greater than 100 knots	1	2	3	4	5
Low level flight	1	2	3	4	5
Contour flight	1	2	3	4	5
NOE flight	1	2	3	4	5
Hovering	1	2	3	4	5
Deceleration	1	2	3	4	5
Normal take-off/landing	1	2	3	4	5

Comments:____

3. Is the stability of the displayed visual scene acceptable?

At a hover	1	2	3	4	5
0 to 50 knots	1	2	3	4	5
50 to 100 knots	1	2	3	4	5
greater than 100 knots	1	2	3	4	5

Comments:____

4. Are the topographical features sufficiently discernible to support flight tasks?

Low level flight 0 to 50 knots	1	2	3	4	5
Low level flight 50 to 100 knots	1	2	3	4	5
Contour flight 0 to 50 knots	1	2	3	4	5
Contour flight 50 to 100 knots	1	2	3	4	5
NOE flight 0 to 50 knots	1	2	3	4	5
NOE flight 50 to 100 knots	1	2	3	4	5
Target acquisition	1	2	3	4	5
Situation awareness	1	2	3	4	5

Comments:____

RATING SCALE

Totally inadequate	Somewhat inadequate	Just adequate enough	More than adequate	Much more than adequate
1	2	3	4	5

5. Is the displayed visual scene adequate to support gunnery tasks in various flight regimes?

Low level flight 0 to 50 knots	1	2	3	4	5
Low level flight 50 to 100 knots	1	2	3	4	5
Contour flight 0 to 50 knots	1	2	3	4	5
Contour flight 50 to 100 knots	1	2	3	4	5
NOE flight 0 to 50 knots	1	2	3	4	5
NOE flight 50 to 100 knots	1	2	3	4	5
Target acquisition	1	2	3	4	5
Situation awareness	1	2	3	4	5

Comments: ____

____

____

6. Check the range at which you feel the AIRNET visual system adequately supports target acquisition tasks.

_____ Not at all
_____ 200 to 500 meters
_____ 500 to 1000 meters
_____ 1000 to 1500 meters
_____ 1500 to 2000 meters
_____ 2000 to 2500 meters
_____ 2500 to 3000 meters
_____ 3000 to 3500 meters
_____ More than 3500 meters

Comments ____

____

____

RATING SCALE

Totally inadequate	Somewhat inadequate	Just adequate enough	More than adequate	Much more than adequate
1	2	3	4	5

VISUAL REPRESENTATION FROM THE FLIR:

7. Check the range at which you feel the AIRNET FLIR adequately supports sensor based target acquisition tasks.

_____ Not at all
_____ 0 to 1000 meters
_____ 1000 to 2000 meters
_____ 2000 to 3000 meters
_____ 3000 to 4000 meters
_____ 4000 to 5000 meters
_____ 5000 to 6000 meters
_____ 6000 to 7000 meters
_____ More than 7000 meters

Comments:____
____
____

FLIGHT CHARACTERISTICS:

8. Does the device fly enough like a helicopter to allow the crewmembers to perform their mission?

1 2 3 4 5

Comments:____
____
____

9. Are the demands on pilot attention required to fly the AIRNET simulated aircraft comparable to the real aircraft?

1 2 3 4 5

Comments:____
____
____

RATING SCALE

Totally inadequate	Somewhat inadequate	Just adequate enough	More than adequate	Much more than adequate
1	2	3	4	5

10. Are the handling characteristics associated with use of the flight controls reasonable comparable to the aircraft?

When input is made to the cyclic	1	2	3	4	5
When input is made to the pedals	1	2	3	4	5
When input is made to the collective	1	2	3	4	5

Comments____

COMMUNICATION SYSTEM:

11. Does the communication system allow crewmembers to transmit information successfully to:

One another	1	2	3	4	5
The tactical operations center (TOC) commander	1	2	3	4	5
Other aircraft	1	2	3	4	5

Comments:____

12. Does the communication system allow crewmembers to receive information successfully from:

One another	1	2	3	4	5
The TOC commander	1	2	3	4	5
Other aircraft	1	2	3	4	5

Comments:____

13. Does the communication system allow crewmembers to monitor two (2) channels simultaneously?

- ______ Not at all
- ______ Totally inadequately
- ______ Somewhat inadequately
- ______ Just adequate enough
- ______ More than adequate
- ______ Much more than adequate

Comments: ____
____
____

A P P E N D I X   D

CREWMEMBER QUESTIONNAIRE (Q2)

Date________________________ Name________________________

Aircraft: ____ Scout
____ Attack

Crewseat:_____ Pilot
_____ Copilot

AIRNET RATING SCALE

Use the scale shown below to rate the performance of the AIRNET device. Circle the performance rating for each of the areas listed. Use the back of page for additional comments if extra space is required. Skip questions that do not apply to your crewseat or aircraft.

RATING SCALE

Totally inadequate	Somewhat inadequate	Just adequate enough	More than adequate	Much more than adequate
1	2	3	4	5

Technical Performance

1. Does the AIRNET local area network provide real time interactive simulation, with no apparent delay, when inputs are made to the following systems:

a) Collective	1	2	3	4	5
b) Cyclic	1	2	3	4	5
c) Pedals	1	2	3	4	5
d) Hover hold	1	2	3	4	5
e) Weapon selection	1	2	3	4	5
f) FLIR/TV selection	1	2	3	4	5
g) Slewing of the TADS	1	2	3	4	5
h) Doppler entry	1	2	3	4	5
i) Doppler correction	1	2	3	4	5
j) Firing 30 mm cannon	1	2	3	4	5
k) Firing HELLFIRE	1	2	3	4	5
l) Firing Stinger	1	2	3	4	5
m) Lasing targets	1	2	3	4	5

Comments:____
____
____

Visual Representation

2. Is the field of view wide enough to enable crewmembers to perform their mission?

a) Forward flight	1	2	3	4	5
b) NOE flight	1	2	3	4	5
c) NOE deceleration	1	2	3	4	5
d) Hovering	1	2	3	4	5
e) Deceleration	1	2	3	4	5
f) Threat detection	1	2	3	4	5
g) Threat avoidance	1	2	3	4	5
h) Formation flight	1	2	3	4	5
i) Situation awareness	1	2	3	4	5

Comments:____

3. Is the forward visual scene realistic enough?

a) For navigation	1	2	3	4	5
b) Calling fires	1	2	3	4	5
c) Adjusting fires	1	2	3	4	5
d) Altitude detection	1	2	3	4	5

Comments:____

4. Is the visual scene smooth and continuous at all times?

a) During flight 0 to 50 knots	1	2	3	4	5
b) During flight 50 to 100 knots	1	2	3	4	5
c) During flight above 100 knots	1	2	3	4	5
d) When encountering the semi-automated forces	1	2	3	4	5

Comments:____

5. Are the topographical features realistic enough for:

a) Negotiating flight	1	2	3	4	5
b) Navigation	1	2	3	4	5
c) Masking/Unmasking	1	2	3	4	5
d) NOE flight	1	2	3	4	5
e) Altitude detection	1	2	3	4	5

Comments: ____

____

____

6. Does the graphic representation allow for target detection (both ground and air vehicles):

Out the Window		FLIR/TV View	
______	Not at all	______	Not at all
______	200 to 500 m	______	0 to 1000 m
______	500 to 1000 m	______	1000 to 2000 m
______	1000 to 1500 m	______	2000 to 3000 m
______	1500 to 2000 m	______	3000 to 4000 m
______	2000 to 2500 m	______	4000 to 5500 m
______	2500 to 3000 m	______	5000 to 6000 m
______	3000 to 3500 m	______	6000 to 7000 m
______	greater than 3500 m	______	greater than 7000 m

Comments ____

____

____

Hardware Fidelity

7. Does the AIRNET sound system accurately portray all systems and weapon sounds?

a) Rotor system	1	2	3	4	5
b) 30 mm gun	1	2	3	4	5
c) HELLFIRE	1	2	3	4	5
d) ATAS	1	2	3	4	5
e) ATAS tone	1	2	3	4	5
f) Own vehicle being hit	1	2	3	4	5
g) Artillery impact	1	2	3	4	5
h) APR 39 tones	1	2	3	4	5

Comments: ____

____

____

8. Does the gunner's station allow the gunner to realistically perform those tasks that he would perform in the attack helicopter?

a) Weapons selection	1	2	3	4	5
b) Search for targets through FLIR	1	2	3	4	5
c) Radio communication	1	2	3	4	5
d) Similar workload levels	1	2	3	4	5
e) Necessary lights, switches, and gauges	1	2	3	4	5

Comments____

9. Does the copilot's station allow the copilot to realistically perform those tasks that he would perform in the scout helicopter?

a) Navigation	1	2	3	4	5
b) Target identification	1	2	3	4	5
c) Radio communication	1	2	3	4	5
d) Similar workload levels	1	2	3	4	5

Comments____

10. Does the pilot's station allow the pilot to realistically perform those tasks that he would perform in the scout helicopter?

a) Negotiate terrain	1	2	3	4	5
b) Seek positions to mask	1	2	3	4	5
c) Anticipate and negotiate obstacles	1	2	3	4	5
d) Fly the aircraft in any intended direction	1	2	3	4	5

Comments____

11. Are all switches and gauges necessary for the pilot to perform the mission present in the simulator? YES NO

Explain____

12. Are all switches and gauges, etc. in a similar location and configuration to those present in the aircraft? YES NO

Explain____
____
____

13. The AIRNET attack module allows the pilot and copilot to maintain visibility with one another. Does this arrangement

[ ] Increase/improve teamwork

[ ] Increase/improve communication between pilot and copilot

[ ] Not affect performance in any way

[ ] Decrease the need to complete communication between the pilot and copilot

[ ] Impair performance between the pilot and copilot

Comments____
____
____

14. The arrangement of the pilot and copilot seat in the same crew module is

[ ] Preferred
[ ] Makes no difference
[ ] Not preferred

Comments____
____
____

<u>Training and Logistics</u>

15. Do the AIRNET exercises demand the same logistics support requirements as the real aircraft?

a) Monitoring ammunition and fuel status	1	2	3	4	5
b) Dispatch, on a real time basis, of fuel and ammunition resupply	1	2	3	4	5

Comments____
____
____

Communication

16. Use the following scale to rate the amount of crew communication that is required to perform the missions listed below.

No Commo	Little Commo	Moderate Commo	High Commo	Constant Commo
1	2	3	4	5

a) Contour flight	1	2	3	4	5
b) NOE flight	1	2	3	4	5
c) Target acquisition	1	2	3	4	5
d) Target engagement - HELLFIRE	1	2	3	4	5
e) Target engagement - ATAS	1	2	3	4	5
f) Target engagement - 30 mm	1	2	3	4	5

Comments ____

____

____

17. How often did you have to verbally cross check your crewmate to ensure he had completed a prescribed task before you proceeded with your tasks?

[ ] Almost never
[ ] Infrequently
[ ] Occasionally
[ ] Frequently
[ ] Almost always

Comments ____

____

____

18. How often did you have to contact the other aircraft in order to complete the mission?

[ ] Almost never
[ ] Infrequently
[ ] Occasionally
[ ] Frequently
[ ] Almost always

Comments ____

____

____

Human Factors

Totally inadequate	Somewhat inadequate	Adequate enough	More than adequate	Much more adequate
1	2	3	4	5

19. Is the AIRNET system similar to the actual aircraft for the crewmembers in terms of comfort?

a) Seats (for at least 2 hours)	1	2	3	4	5
b) Seats (for more than 2 hours)	1	2	3	4	5
c) Location of collective	1	2	3	4	5
d) Distance of screens from the pilot	1	2	3	4	5
e) Distance of screens from the instrument display	1	2	3	4	5
f) Location of the instrument display	1	2	3	4	5
g) Height of the screens with respect to the pilot	1	2	3	4	5
h) Orientation of the pedals	1	2	3	4	5

Comments ____

20. Does the fidelity of the visual representation differ from the actual aircraft in terms of

a) Eye fatigue	1	2	3	4	5
b) Eye strain	1	2	3	4	5
c) Blurred vision	1	2	3	4	5

Comments ____

21. Are the instrument displays easily readable and understandable? YES NO

Comments ____

22. Does use of the AIRNET device result in any adverse physiological effects?

Before	During	After	
______	______	______	a) General discomfort
______	______	______	b) Fatigue
______	______	______	c) Drowsiness
______	______	______	d) Headache
______	______	______	e) Difficulty focusing
______	______	______	f) Sweating
______	______	______	g) Nausea
______	______	______	h) Difficulty concentrating
______	______	______	i) Blurred vision
______	______	______	j) Dizziness (eyes open)
______	______	______	k) Dizziness (eyes closed)
______	______	______	l) Vertigo
______	______	______	m) Faintness
______	______	______	n) Stomach awareness

Comments____
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Negative Habit Transfer

23. Please use the scale from the Human Factors section to respond to the following questions. Due to your experience in the AIRNET device, have you experienced any adverse performance effects in the actual aircraft for the following tasks?

a) Forward flight 0 to 50 knots	1	2	3	4	5
b) Forward flight 50 to 100 knots	1	2	3	4	5
c) Forward flight greater than 100 knots	1	2	3	4	5
d) Low level flight	1	2	3	4	5
e) Contour flight	1	2	3	4	5
f) NOE flight	1	2	3	4	5
g) Formation flight	1	2	3	4	5
h) Hovering	1	2	3	4	5
i) Deceleration	1	2	3	4	5
j) Acceleration	1	2	3	4	5
k) Normal takeoff/landing	1	2	3	4	5
l) Cyclic overcontrol	1	2	3	4	5
m) Collective input	1	2	3	4	5
n) Staying in trim	1	2	3	4	5
o) Communication procedure	1	2	3	4	5
p) Increased communication	1	2	3	4	5
q) Decreased communication	1	2	3	4	5

Comments____
____
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Training Value

24. Please use the following scale to determine the value of the AIRNET device as it is currently configured for training the following tasks.

Not desirable	Desirable	Very desirable	Highly desirable	Extremely desirable
1	2	3	4	5

a) Tactics/mission planning and briefing	1	2	3	4	5
b) Medium/high altitude tactics	1	2	3	4	5
c) Low level flight	1	2	3	4	5
d) Low altitude tactics	1	2	3	4	5
e) NOE flight	1	2	3	4	5
f) Low threat tactics	1	2	3	4	5
g) High threat tactics	1	2	3	4	5
h) Tactical formation	1	2	3	4	5
i) 2-ship tactics	1	2	3	4	5
j) 4-ship tactics	1	2	3	4	5
k) Visual ID	1	2	3	4	5
l) Tactical intercept	1	2	3	4	5
m) Missile employment	1	2	3	4	5
n) Gun employment	1	2	3	4	5
o) Safe passage	1	2	3	4	5
p) Egress tactics	1	2	3	4	5
q) Movement to contact	1	2	3	4	5
r) Communication procedure	1	2	3	4	5
s) Call for fire	1	2	3	4	5
t) Adjust fire	1	2	3	4	5
u) Close air support	1	2	3	4	5
v) Target handover	1	2	3	4	5
w) Reconnaissance missions	1	2	3	4	5
x) Screening operations	1	2	3	4	5
y) Target engagement	1	2	3	4	5

Comments ______________________________